United States Department of Agriculture

Burnt Corral Vegetation Management Project

Soil, Watershed, and Air Specialist's Report

Forest Service | Kaibab National Forest | North Kaibab Ranger District | May 2018

Summary

The USDA Forest Service (FS), Kaibab National Forest, North Kaibab Ranger District (NKRD) proposes the Burnt Corral Vegetation Management Project (hereinafter-referred-to-as "Burnt Corral") to improve forest health and habitat conditions and make them more resilient to disturbances such as wildfire or climate change. Through a collaborative process with interested stakeholders, the NKRD proposes to mechanically thin up to about 15,070 acres and use wildland fire (including, for this project, both managed and prescribed fire) alone or in conjunction with mechanical treatment on up to about 28,060 acres. The project is within the area prioritized by the Kaibab Forest Health Focus (KFHF), a collaborative, science-based group that has helped guide landscape-level forest restoration efforts across the Kaibab National Forest (KNF). The Burnt Corral Vegetation Management Project is the first in a series of efforts to restore forest health, beneficial fire regimes, and wildlife habitat in the ponderosa pine belt on the west side of the Kaibab Plateau.

The purpose of this project is to achieve desired conditions as defined in the Forest Plan (USDA FS, 2014), consistent with prioritized areas as identified by the Kaibab Forest Health Focus (KFHF; NAU 2009). There is a need to: a) increase diversity in forest stand structure and species composition, b) increase native grasses, forbs, and shrubs within openings throughout the project area, c) maintain existing system of roads and prevent development of new roads, d) reduce the acres of non-native vegetation, and allow for native vegetation succession.

The project area is approximately 28,060 acres in size and lies within the southwest portion of the Kaibab Plateau, south-southwest of Lookout Canyon and Forest Service Road (FSR) 22, on the North Kaibab Ranger District (NKRD), of the Kaibab National Forest (KNF). The project lies within Townships 35-37 North, Ranges 1 West -1 East, in Coconino County, Arizona, Gila and Salt River Baseline and Meridian.

Within the proposed project area, the majority of the ponderosa pine vegetation type is located west of FSR 22, with the project area bounded by FSR 447 to the north, FSR 226 to the east, FSR 203/203A and the FSR 425 to the south, and FSR425 and 427 to the west. Approximately 7,530 acres on the western side of the project area overlaps with the 1996 Bridger Knoll wildfire. This area is now dominated by early seral species including New Mexico locust (*Robinia neomexicana*) and Gambel oak (*Quercus Gambelii*).

The overall objective of the Burnt Corral vegetation management project, which is consistent with the Forest Service's mission statement, is to improve ecosystem resilience and function at the landscape scale in order to sustain healthy forests and watersheds for future generations.

Based on field reconnaissance, reviews of literature, available data and information, and GIS analysis, long-term adverse impacts to soil productivity and watershed condition are not anticipated from any of the proposed activities, if implemented judiciously and with application of Best Management Practices (BMPs) and Soil and Water Conservation Practices (SWCPs). The proposed treatments would not exceed regional thresholds for soil erosion, water quality, watershed condition, or air quality, assuming harvesting is conducted under dry or frozen ground conditions on pre-defined and maintained access routes, including skid trails. The initial use of prescribed fire in treatment areas is expected to increase the risk of erosion on some soils due to current fuel loads and anticipated fuel loads following forest thinning. When these fuels burn, areas would likely occur where little to no vegetative cover would remain, increasing the susceptibility of these sites to accelerated erosion. With appropriate mitigation measures and implementation of Best Management Practices (BMPs) and Soil and Water Conservation Practices (SWCPs) as outlined in this report, these adverse impacts are expected to be minimized and short-term.

Contents

Summary i
Chapter 1. Purpose of and Need for Action 5
Introduction 5
Background 5
Purpose and Need for Action 5
Proposed Action 7
Methodology and Analysis Process 1
Issues 14
Soil, Water, and Air Resource Condition Indicators 15
Kaibab National Forest Land Management Plan Direction 15
Relevant Laws, Regulations, and Policies that Apply 17
Resource Protection Measures 24
Chapter 2. Alternatives, Including the Proposed Action 29
Introduction 29
Alternatives 29
Comparison of Alternatives 29
Chapter 3. Affected Environment and Environmental Consequences 37
Affected Environment 37
Environmental Consequences 43
Recommendations 56
Certification 57
References 57
Appendix A – Burnt Corral Project Area Soils and Watershed Map 61
Appendix B – Burnt Corral Project Soil Condition Field Assessment Information 63
Appendix C – Watershed Condition Indicator Ratings and Watershed Condition Summary 61

List of Tables

Table 1. Resource protection measures required for Proposed Action. 24
Table 2. Summary of effects to soils and watersheds for each alternative considered. 30
Table 3. Terrestrial Ecosystem Survey (TES) soil map units located in the Burnt Corral project area and their associated acreages. 39
Table 4. Soil conditions, erosion hazard ratings, slope ranges and modeled erosion rates for forest thinning and prescribed fire on TES map units in the Burnt Corral project area. Highlighted map would not receive mechanical thinning treatments. 39

List of Figures

Figure 1. Core national watershed condition indicators. 14

Chapter 1. Purpose of and Need for Action

Introduction

This report is the specialist's report for soil, water, and air resources related to the proposed Burnt Corral Vegetation Management Project. The purpose of this report is to provide detailed information and analysis regarding soils and watershed resources in order to support the conclusions in an Environmental Assessment (EA). This report will provide a brief description of the project; discuss key assumptions and methodologies used in the analysis; identify existing inventories, monitoring, and research literature used in the analysis; describe desired conditions and site-specific resource conditions; discuss resource impacts and effects of the proposed action and alternatives; recommend site-specific mitigation measures to minimize or avoid these effects; and identify specifically required disclosures for soil resources.

Background

The Kaibab Forest Health Focus (KFHF), a science-based collaborative process to identify priority treatment areas across the Kaibab National Forest, was completed in 2009. The KFHF identified priority treatment areas and developed initial treatment guidance across the KNF. The findings of KFHF were incorporated into the revised KNF Land and Resource Management Plan (LRMP) as priority landscapes in need of management attention. The Burnt Corral project area was identified as highest priority for management attention by stakeholders in the KFHF. The project provided opportunity for stakeholders, including those involved in the KFHF and others interested in forest management on the NKRD, to contribute to the planning process. The Burnt Corral project is the first landscape-scale restoration project on the NKRD that falls under the 2014 revised LRMP for the Kaibab National Forest.

Purpose and Need for Action

Purpose 1: Make progress toward desired conditions defined in the Forest Plan (USDA FS, 2014) and consistent with prioritized areas, as identified by the KFHF, with an emphasis on:

a) Improving forest health and vigor, while enhancing habitat conditions to make them more resilient to change in the event of wildfire and other changes in climate or related stressors (i.e., drought, large bark beetle infestations). To achieve this, there is a need to:
   - Return ponderosa pine forest to a fire adapted ecosystem (i.e., high frequency – low intensity surface fires).
   - Manage fire in first entry and follow-up prescribed fire treatments
   - Retain large and old ponderosa pine trees while reducing heavy fuel loads and overly dense stands of smaller trees present in many portions of the project area.
   - Restore forest structure and processes (including natural disturbances such as low-severity fire, watershed function, and nutrient cycling). More specifically this includes:
     - Reducing the risk of uncharacteristic and undesirable wildland fire effects (i.e., either active or passive crown fire), with an emphasis on restoring and maintaining desirable plant community attributes, including fuel levels, fire regimes, and other ecological processes.
     - Maintaining and restoring upland area vegetation, and reducing erosion

within the ephemeral drainages (i.e., within drainages and bare ridgelines that drain to the west and southwest and comprise a significant portion of the Kanab Creek watershed).

- Improving watershed conditions and reducing road-related impacts to natural and cultural resources. To achieve this, there is a need to:
  - Increase diversity in forest stand structure and species composition.
  - Increase native grasses, forbs, and shrubs within openings throughout the project area.
  - Maintain the existing system of roads and prevent development of new roads.
  - Reduce the acres of non-native vegetation, and allow for native vegetation succession.

b) Restoring the ponderosa pine forest type to increase resilience to disturbance, improve forest health, and improve habitat. To achieve this, there is a need to:
   - Reduce tree density and Stand Density Index (SDI) to the lower range of site occupancy (about 35 – 40% of max SDI in ponderosa pine).

c) Meet KNF LRMP objectives at the mid-scale for desired basal area ranges in the 60 – 80 sq. ft. per acre range with larger trees (i.e. > 18 inches in diameter) contributing the greatest percent of the total basal area, with some areas containing 10 to 20 percent higher basal area in mid-aged to old tree groups than in the general forest (e.g. goshawk post-fledging family areas Mexican spotted owl nesting/roosting habitat, drainages, and steep north-facing slopes).

   - Mechanically thin up to about 15,000 acres.
   - In up to about 5,000 additional acres, perform hand thinning and light mechanical treatment using low-ground pressure equipment for preparation thinning for use and management of prescribed fire and managed wildfire
   - Stimulate oak regeneration.
   - Stimulate aspen regeneration in the project area especially where it currently exists and at the head of draws, ephemeral streams, and hollows.
   - Retain remnant, surviving pine trees in the overlap of the burned area of the 1996 Bridger Knoll fire (about 60,000 acres burned).
   - Protect existing ponderosa pine plantations that have been established from the reforestation programs following the Bridger Knoll salvage timber sales.
   - Reduce the risk of hazardous, stand-replacing crown fire events in the entire project area, especially portions of the project area that have received no timber treatments nor experienced fire events in the last 25 years.
   - Promote uneven-aged forest where lacking, maintain current uneven-aged forest, and create openings in older even-aged stands with patch cuts from one-half to four acres, distributed randomly across the landscape.
   - Restore fire-prone stands to more open, historic condition.
   - Establish fuel breaks along major forest roads like FSR422, 255, and 425 to provide public safety and protection for firefighters if a high intensity, fast moving crown fire event occurred.
   - Create openings (utilizing "Group Selection" cuts), which range in size from ½ acre, up to 4 acres, with a maximum width of 200-feet for any opening 2 acres or greater in size. Openings would be laid out in a random mosaic pattern within treatment units. Selected seed trees would be left in openings greater than 2 acres to maintain and promote desired or healthier genetic traits.

d) Maintain and promote a ponderosa pine/frequent fire forest vegetation community that is a mosaic of forest conditions composed of structural stages ranging from young to old trees.

Proposed Action

The NKRD, through a collaborative process with interested stakeholders, proposes to mechanically thin up to about 15,070 acres and use wildland fire (including, for this project, both managed and prescribed fire) alone or in conjunction with mechanical treatment on up to about 28,060 acres. This proposed action is based on consultation with diverse stakeholders and guided by a quantitative exploration of existing data that allowed explicit consideration of multiple values and perceived risks associated with this project and the 2009 Kaibab Forest Health Focus. In pursuing this stakeholder process, the NKRD has endeavored to integrate the broad experience and expertise of stakeholders into a proposed action that would achieve project objectives at multiple scales, consistent with the results from KFHF and the Forest Plan.

Wildland Fire

Treat up to 12,990 acres using wildland fire management. Throughout this document, wildland fire refers to prescribed fire as well as managed wildfire, and includes activities such as preparation thinning (typically achieved through hand thinning and/or the use of mastication head or similar small, low ground pressure equipment), the construction of control lines, and other treatments associated with appropriate use and management of prescribed fire and managed wildfire.

1. Actions in the Bridger Fire Area (up to about 7,560 acres)
    - Use wildland fire and spot treatments of prescribed fire, as needed, to achieve management objectives
    - Protect existing regenerating trees from fire and mechanical activities as appropriate to meet management objectives
    - Minimize seed-dispersing agents and soil disturbance activities to lessen or avoid the spread of cheatgrass (*Bromus tectorum*).
    - Monitor and implement control measures for invasive species, such as cheatgrass
    - Develop burn plans in consultation with the Arizona Game and Fish Department to ensure wildlife habitat objectives are met.
2. Sensitive Soils and Steep (40% or greater) Slopes (up to about 5,010 acres)
    - Use wildland fire to burn when needed to achieve management objectives
    - Where fuel loading could result in undesirable fire effects, use preparation thinning (either hand thinning or small, low-ground pressure equipment) and piling in preparation for wildland fire
    - Mitigate and avoid negative impacts to sensitive areas by using best management practices and design criteria for soils protection
3. Ponderosa Pine Seed Tree Cuts Approaching Desired Conditions (up to about 420 acres)
    - Use wildland fire to burn when needed to achieve management objectives

Mechanical Thinning and Wildland Fire

Treat up to 15,070 acres using both mechanical thinning and fire.

4. Ponderosa Pine Forest: Northern Goshawk Nest Areas (up to about 2,580 acres).

Within areas designated for Northern Goshawk nests or replacement nest areas, about 415 acres are also areas of steep slopes and sensitive soils and would be treated under those guidelines.

4.1 Mechanical Treatment

- Where needed to protect and/or enhance nesting habitat, thin from below up to 14"dbh in goshawk nest areas
- Manage for or retain snags, downed logs, woody debris and old trees, whenever possible

4.2 Wildland Fire

- Where possible, use wildland fire in preference to or in coordination with mechanical treatments
- Wildland fire use may occur pre-or-post mechanical treatment, and multiple fire entries may occur over the project life.

5. Ponderosa Pine Forest: Old Growth Patches (up to about 2,600 acres)
This is a significant portion of the project area that supports relatively dense stands of pre-European settlement trees and retains conditions consistent with pre-European settlement ponderosa pine ecosystems. Some of these areas have been identified as candidate old growth protection sites (henceforth "old growth patches"). However, currently available data are not sufficient for mapping the locations of old growth patches. Access to Forest Service stand data, combined with field validation of both stand data and Northern Arizona University's Landscape Cooperative Initiative (LCI) forest structural models will allow spatially explicit depiction of these patches during NEPA analysis. Preliminary analysis based largely on previous LCI models and guidance provided at the Kanab meeting of the Burnt Corral Stakeholders Group, suggest that a combined area of approximately 2,600 acres would capture most continuous patches of ponderosa pine forest exhibiting old growth conditions. The intent of identifying these old growth patches is to protect areas recognized as current and future reservoirs of old growth forest composition, structure and function. These areas w o u l d be managed in conjunction with design features for retaining old and large trees, generally (see below), to ensure the adequate representation of the composition, structure and function of old growth stands, including their living and non-living components, into the future.

5.1 Mechanical Treatment

- Conduct limited mechanical treatments that thin post settlement trees less than 16 inch dbh as necessary to reduce ladder fuels
- Retain structural diversity
- Retain old growth components including large snags, downed logs, coarse woody debris, and large and old trees

5.2 Wildland Fire

- Use wildland fire in coordination with mechanical treatments
- Wildland fire use may occur pre- or post-mechanical treatment, and multiple fire entries may occur over the project life

6. Ponderosa Pine Forest: Remaining Area (Up to about 9,530 acres)
For the remaining acres of ponderosa pine, including Northern Goshawk PFAs (about 9,320 acres), the following actions are proposed:

6.1 Mechanical Treatment

- Use group selection cuts varying in shape to create opening that are an irregular and heterogeneous forest mosaic, characterized by treatments from ¼ to 4 acres in size, with a maximum width of 200 feet. The intent of these selection cuts is to manage for current and future uneven-aged conditions while reducing fuel loads and fuel continuity, without creating an homogeneous stand structure or a regular or repetitive "cookie cutter" structure of alternating dense stands and openings.
- Strategically place treatments and vary the sizes of thinned areas on the landscape, taking advantage of topography and roads, particularly East-West roads, to achieve fire management objectives
- Generally, treat more intensively on south-facing slopes and areas upwind of NOGO nest areas, old growth patches, and other areas of denser trees of particular value or vulnerability to fire
- Generally forego mechanical treatment in areas where fire models predict passive surface fire
- Develop and/or maintain structural diversity, including some areas with interlocking crowns and wildlife hiding cover at the stand level
- Develop and/or maintain at least 3 age classes in roughly even proportions across any 100-1,000 acre subunit

6.2 Wildland Fire

- When possible, use wildland fire in coordination with mechanical treatments
- Wildland fire use may occur pre- or post-mechanical treatment, and multiple fire entries may occur over the project life

7. Mexican Spotted Owl Habitat (Up to 358 acres)

Three hundred and fifty eight acres of the project is designated as Mexican spotted owl Recovery Habitat and would be managed consistent with the Mexican Spotted Owl Recovery Plan (2012). About one hundred eighty acres of Recovery Habitat overlap with steep slopes and sensitive soils. Any guidelines developed for steep slopes and sensitive soils would be used as operational guidance and would conform to the Recovery Plan. All treatments would move the habitat towards Nesting/Roosting Habitat desired conditions within the Recovery Plan (Table C.3, pg. 278).

7.1 Mechanical Treatment

- Thin from below up to 12" DBH, in some cases thinning may only occur up to 9" DBH to meet desired conditions.
- Multiple mechanical entries may be required during the life of the project to meet desired conditions.
- Retain Mexican spotted owl key habitat elements required by the Recovery Plan. These elements include hardwoods, large snags (>18" DBH), large downed logs (>18" DBH at any point), and large trees (>18" DBH).
- Maintain the Primary Constituent Elements (PCEs) of Mexican spotted owl Critical Habitat. Areas outside of Recovery Habitat (i.e. Ponderosa pine) would be treated to protect the habitat from uncharacteristic high intensity wildlife and other natural disturbances.

7.2 Wildland Fire

- Wildland fire would be implemented as appropriate to retain the key elements mentioned above in 7.1 as well Critical Habitat PCEs.
- Prescribed fire may occur pre- or post-mechanical treatment. Multiple fire entries may occur over the life of the project within Recovery Habitat to meet desired conditions.

Other Included Actions

- Encourage reestablishment of aspen in ponderosa pine-dominated stands by centering thinning efforts in areas with remaining aspen trees, when feasible
- Retain existing stands of Gambel oak, including all oak >8 inches diameter at root collar. Encourage reestablishment in ponderosa pine-dominated stands by centering thinning efforts in areas with oak
- Install artificial bat barks near permanent and ephemeral water sources throughout the project area.
- Work in collaboration with Arizona Game and Fish Department to evaluate existing water developments and, where appropriate, refurbish for the purpose of enhancing wildlife habitat.
- Reduce fuels and control erosion at fire-sensitive cultural resource sites.
- Provide local tribes continued access to forest resources and opportunities to engage in traditional practices.

Methodology and Analysis Process

This section describes the methodology and analysis processes used to determine the environmental consequences to soils, watershed, and air resources from implementing the alternatives. Environmental consequences will be described with qualitative and quantitative descriptions supported by past studies, field observations, and relevant literature.

Analyses for environmental consequences to soils, watershed and air resources that may result from implementation of each alternative were conducted using information contained in the Terrestrial Ecosystem Survey of the Kaibab National Forest (TES)(Brewer et al. 1991), the Watershed Condition Framework, the Kaibab National Forest Land Management Plan, as amended (2014), information obtained from other KNF resource specialists, other agency reports, available literature, field visits to validate site conditions, and input from KNF collaborators and cooperators. Geospatial analysis was used to quantitatively and qualitatively assess soils and watershed conditions using Geographic Information Systems (GIS) data obtained from a variety of sources.

Field assessments were conducted to validate current soils conditions and to determine appropriate mitigation measures to prevent adverse effects to soils, water quality and watershed condition from mechanical vegetation treatments, timber harvesting, and prescribed fire. Soil condition assessment information and field data sheets are included in Appendix A.

Soils of the KNF were mapped as part of the Terrestrial Ecosystem Survey (TES) of the Kaibab National Forest (Brewer et al. 1991 with addendum 5/12/1995). This information is available at the Kaibab National Forest Supervisor's Office or via the internet at:

Kaibab National Forest Terrestrial Ecosystem Survey Manuscript

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5138598.pdf

Soil erosion rates for forest thinning and prescribed fire were modeled using FS WEPP Interfaces.

The FS WEPP interface allows users to easily describe numerous disturbed forest and rangeland erosion conditions. The interfaces present the results as a summary and extended WEPP outputs, and also present the probability of a given level of erosion occurring the year following a disturbance. Values for predicted soil erosion rates by water movement were determined from rainfall simulations and field research of natural rainfall effects conducted by scientists within the USDA and other organizations (Elliot and Foltz 2001). The WEPP model has been further validated for use in the Southwest (i.e., Arizona and New Mexico) through research on hydrologic processes to predict responses of soils to disturbances (Ward and Bolton 1991, Paige et al. 2003).

Sediment yield rates for forest thinning and prescribed fire treatments were modeled for each watershed within the project area using the WEPP Fuel Management (FuME) model. The WEPP FuME tool was developed to estimate sediment generated by fuel management activities. WEPP FuME estimates sediment generated for 12 fuel-related conditions from a single input. These conditions include: undisturbed forest, three severities of wildfire, three severities of prescribed fire, two forest thinning intensities, and three levels of road traffic. The tool is designed to be used by erosion specialists for detailed analysis of impacts of proposed fuel treatments, or by fuel management specialists for a quick estimate of potential sedimentation impacts from a given stand treatment. Slope percentages were weighted by their associated acreages within each watershed in the project area in order to provide the most accurate prediction of potential accelerated soil erosion and sediment yield from proposed treatments. Low, moderate, and high severity fire conditions were modeled for prescribed fire treatments in order to cover the range of possible burn conditions. Erosion rates for existing forest roads were also modeled using the WEPP:Road interface. WEPP:Road is an interface to the WEPP soil erosion model that allows users to easily describe numerous road erosion conditions. WEPP:Road is designed to predict runoff and sediment yield from roads, compacted landings, compacted skid trails, and compacted foot, cattle, or off-road vehicle trails.

Effects to water quality will be assessed qualitatively by alternative by comparing predicted direct, indirect, and cumulative effects by major land disturbing activities (e.g. forest thinning, temporary road construction and decommissioning, debris piling, pile burning, and prescribed fire) within the project area.

The general classification used for surface water quality by ADEQ is attaining, attaining some uses, inconclusive/not assessed, not-attaining, and impaired for the identified uses. The classification designates each waterbody in one of five categories:

Category 1 Surface waters assessed as "attaining all uses." All designated uses are assessed as "attaining."

Category 2 - Surface waters assessed as "attaining some uses." Each designated use is assessed as either "attaining," "inconclusive," or "threatened."

Category 3 - Surface waters assessed as "inconclusive." All designated uses are assessed as "inconclusive" due to insufficient data to assess any designated use (e.g., insufficient samples or core parameters). By default, this category would include waters that were "not assessed" for similar reasons

Category 4 - Surface waters assessed as "not attaining." At least one designated use was assessed as "not attaining" and no uses were assessed as "impaired." A Total Maximum Daily Load[1] (TMDL) analysis will not be required at this time for one of the following reasons:

4 A. - A TMDL has already been completed and approved by EPA but the water quality standards are not yet attained;

4 B. - Other pollution control requirements are reasonably expected to result in the attainment of water quality standards by the next regularly scheduled listing cycle; or

4 C. - The impairment is not related to a "pollutant" loading but rather due to "pollution" (e.g., hydrologic modification).

Category 5 - Surface waters assessed as "impaired." At least one designated use was assessed as "impaired" by a pollutant. These waters must be prioritized for TMDL development.

Water quality is assessed by comparing existing conditions (categories 1 to 5 above) with desired conditions that are set by Arizona under authority of the Clean Water Act. The Arizona Department of Environmental Quality (ADEQ) is the regulating authority for water quality in Arizona as promulgated by EPA. Waters that are not impaired (those not on 303d[2] list or in category 4 or 5) are providing for beneficial uses identified for that stream or water body and can be considered in a desired condition until further sampling indicates impairment. Those in category 2 or higher require special attention during site specific project analysis. The ADEQ also interprets its surface water quality standards to apply to "intermittent, non-navigable tributaries." The ADEQ interprets the definition of "surface water" to include tributaries ("the tributary rule") and assigns water quality standards to intermittent surface waters that are not specifically listed by name in Arizona's surface water quality standards rules. ADEQ has determined it is necessary to regulate and protect these types of waters as "waters of the United States" because it is estimated that approximately 95 percent of the surface waters in Arizona are either intermittent or ephemeral.

Effects to water yield will be discussed qualitatively, based on comparison of current activities to projected effects of implementing alternatives. Generally, reducing canopy cover in vegetation types within higher precipitation zones will generate more runoff.

Effects to groundwater availability will be discussed qualitatively using regional studies and FS policies to generally predict effects to the forests. There is no difference between alternatives regarding groundwater use or groundwater quality, and slight differences predicted in groundwater recharge potential from the Forest.

A watershed condition assessment was completed in 2011 for all sixth-level subwatersheds in the proposed project area as part of a Forest-level assessment of watershed condition (Potyondy and Geier, 2010). Watershed conditions were re-evaluated in 2016 to account for changes in watershed

[1]A TMDL is a written analysis that determines the maximum amount of a pollutant that a surface water can assimilate (the "load"), and still attain water quality standards during all conditions. The TMDL allocates the loading capacity of the surface water to point sources and nonpoint sources identified in the watershed, accounting for natural background levels and seasonal variation, with an allocation set aside as a margin of safety.

[2] Under section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. (http://www3.epa.gov/region9/water/tmdl/303d.html)

conditions due to restoration treatments, road decommissioning, wildfires and other agents of change since the initial assessment. Watershed condition was classified using a core set of national watershed condition indicators that were updated with local data and interpreted by a Forest interdisciplinary (ID) team. These indicators are grouped according to four major ecosystem process categories: (1) aquatic physical; (2) aquatic biological; (3) terrestrial physical; and (4) terrestrial biological. These categories represent terrestrial, riparian, and riverine ecosystem processes or mechanisms by which management actions can affect the condition of watersheds and associated resources. Each indicator was evaluated using a defined set of attributes whereby each attribute was scored by the Forest interdisciplinary team as GOOD (1), FAIR (2), or POOR (3) using written criteria, rule sets, the best available data, and professional judgment.

Twelve core watershed condition indicators were evaluated for all sixth-level HUCs. Aquatic physical indicators included: 1) water quality condition, 2) water quantity (flow regime) condition, and 3) stream and habitat condition. Aquatic biological indicators included: 4) aquatic biota condition and 5) riparian vegetation condition. Terrestrial physical indicators included: 6) road and trail condition, and 7) soil condition. Terrestrial biological indicators included: 8) fire effect and regime condition, 9) forest cover condition, 10) rangeland, grassland and open area condition, 11) terrestrial non-native invasive species condition, and 12) forest health condition.

Attribute scores for each indicator were summed and normalized to produce an overall indicator score. The indicator scores for each ecosystem process category were then averaged to arrive at an overall category score. The Watershed Condition scores were tracked to one decimal point and reported as Watershed Condition Classes 1, 2, or 3. Class 1 = scores of 1.0 to 1.7; Class 2 = scores >1.8 and <2.3, and Class 3 = scores from 2.4 to 3.0. Class 1 watersheds are functioning properly. Class 2 watersheds are functional – at risk, and Class 3 watersheds have impaired function.

Figure 1 below displays the watershed condition indicators and how each attribute contributes to indicator ratings and overall evaluation of watershed condition classification.

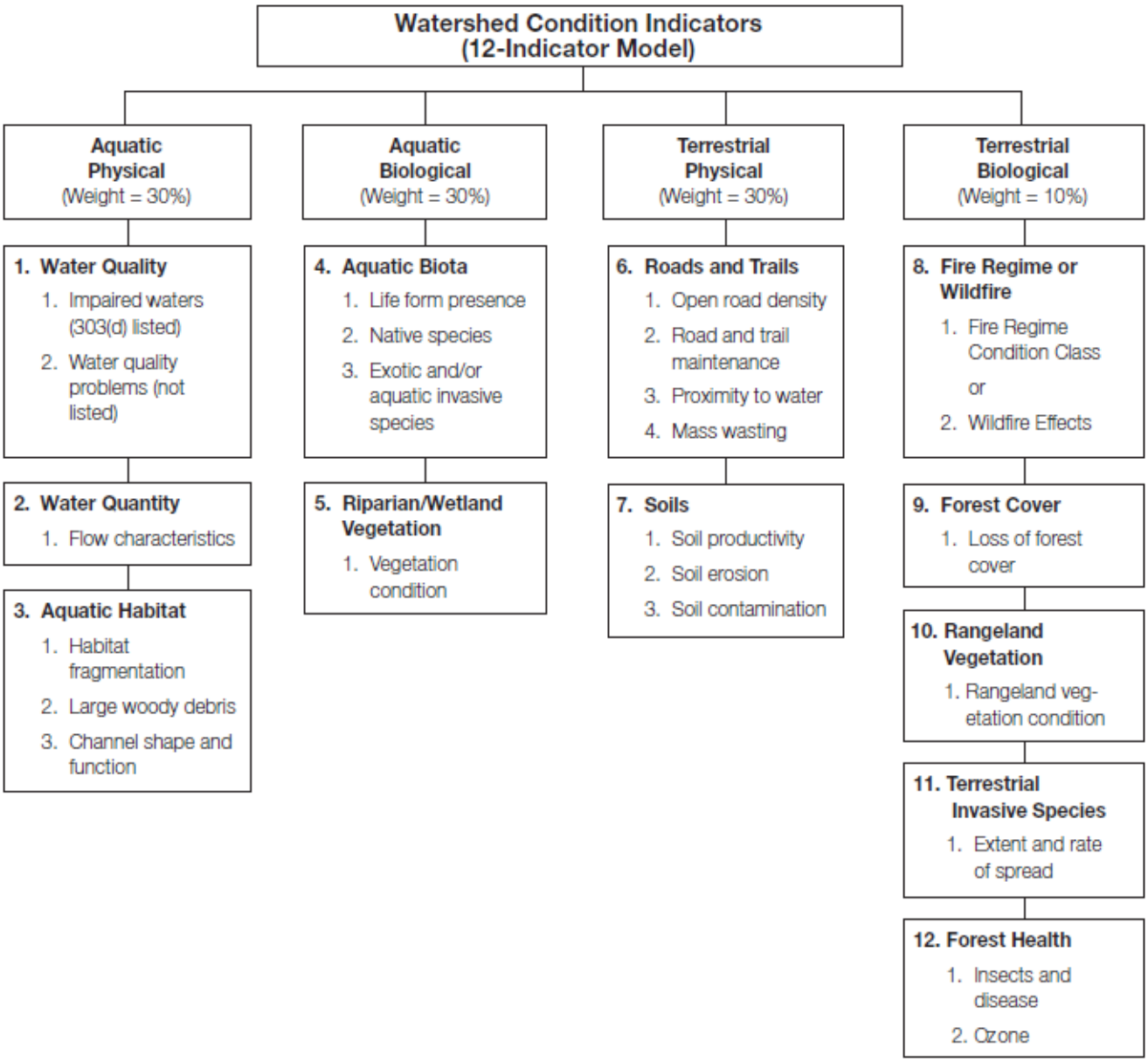


Figure 1. Core national watershed condition indicators.

Soils, Watershed and Air Issues for the Burnt Corral Project

Soils and watershed issues include:

- Percent of soil exposure across the treatment areas
- Percent of soil disturbance across the treatment areas
- Construction of temporary roads could increase surface runoff, erosion, and sediment delivery to ephemeral drainages.
- Construction of firelines, piling and burning of activity-related debris could disturb, destabilize, and compact soils and expose them to erosion.

- Burning of large debris piles can create enough heat to sterilize the underlying soils and create hydrophobic conditions, exposing those sites to erosion for an extended period of time.
- The amount of vegetation removed through fuels treatments and the use of prescribed fire could increase short-term erosion rates.
- Potential for soil rutting, compaction, and puddling caused by mechanical fuels treatments.
- The amount of sediment that reaches ephemeral streams or drainages (displayed as embeddedness) could increase.
- Cumulative effects to soils and watershed resources, when combined with past, present, and reasonably foreseeable future actions could be significant.
- There is need to retain adequate amounts of coarse woody debris, including large logs, necessary to protect soil surfaces from erosion and provide wildlife habitat components for soil micro and macro-fauna.

Air quality issues include:

- Particulate emissions form prescribed and managed fires that could adversely affect human health.
- Dust from roads could affect visibility and adversely affect human health
- Impaired visibility in areas affected by smoke
- Nuisance smoke

Soil, Water, and Air Resource Condition Indicators

For soils resources, the units of measure of effects to soils will be the acres of ground disturbance from equipment use and acres subjected to high severity fire. The units of measure for watershed resources are sediment delivery to ephemeral drainages or changes to channel morphology, displayed as embeddedness, changes in channel sinuosity, downcutting or incision, and bank failure or slumping. For water quality measures, no measurements will be taken to determine water quality. A narrative description will explain the effects to water quality from each alternative. Most adverse effects to soils and water resources can be minimized or mitigated through use of resource protection measures such as Soil and Water Conservation Practices (SWCPs) and Best Management Practices (BMP's) as outlined in the Soil and Watershed Conservation Practices Handbook (Forest Service Handbook 2509.22)(USDA 1990) and the National Core BMP Technical Guide (FS-990a).

Kaibab National Forest Land Management Plan Direction

Desired Conditions

Soils

- Soils provide for diverse native plant species. Vegetative ground cover is well distributed across the soil surface to promote nutrient cycling and water infiltration.

- Accelerated soil loss is minimal, especially on sensitive or highly erodible sites.

- Soils can readily absorb, store, and transmit water vertically and horizontally; accept, hold, and release nutrients; and resist erosion.

- Infiltration rates are good in TES soil units that are described as well drained and moderately well drained.
- Logs and other woody materials are distributed across the surface to maintain soil productivity.
- Biological soil crusts (mosses, lichens, algae, liverworts) are stable or increasing in semi-desert grasslands, desert, pinyon-juniper, and sagebrush communities.
- Soils are free from anthropogenic contaminants that could alter ecosystem integrity or affect public health.
- Soils are serving as effective organic carbon sinks in order to prevent soils from contributing to increased atmospheric carbon.

Watersheds

- Vegetation conditions within watersheds contribute to downstream water quality and quantity. Surface runoff, sheet, rill, and gully erosion, and subsequent sedimentation into connecting waters downstream is minimal.
- Flooding maintains normal stream characteristics (e.g., water transport, sediment, woody material) and dimensions (e.g., bankfull width, depth, slope, and sinuosity). Vertical down cutting and embeddedness are absent in drainages.
- Flood plains are functioning and lessen the impacts of floods on human safety, health, and welfare.
- The fuels composition within watersheds does not put the watersheds at risk for uncharacteristic disturbance.

Water Quality

- Water quality meets or surpasses State of Arizona or Environmental Protection Agency water quality standards for designated uses. Water quality meets critical needs of aquatic species.

Air Quality

- Air Quality meets or surpasses State and Federal ambient air quality standards.
- Management activities on the Kaibab NF do not adversely impact Class I airshed visibility as established in the Clean Air Act.

Guidelines

Soils and Watershed Management

- Projects should incorporate the national best management practices for water quality management and include design features to protect and improve watershed condition.
- In disturbed areas, erosion control measures should be implemented to improve soil conditions.

- Seeds and plants used for revegetation should originate from the same PNVT and general ecoregion (i.e. southern Colorado Plateau) as the project area.

Natural Waters

Access to natural waters should be restricted to designated trails and points of entry to mediate erosion and prevent trampling and inadvertent introduction of nonnative and undesirable biota and disease.

- Activities in and around waters should use decontamination procedures to prevent the spread of chytrid fungus.
- Fences constructed around natural waters should allow bats and other desirable wildlife to pass through unharmed.
- Diversions of water sources that recharge wetlands should be assessed and appropriate actions should be identified to mitigate or minimize effects.
- Spring source areas should be preferentially protected.
- Forest springs information should be maintained in a database that facilitates long-term archiving, easy data entry, and comparison with monitoring results.
- Water rights for springs should be secured where there are no existing water rights or claims.
- The impacts of management activities on springs, streams, and wetlands should be evaluated and minimized.

Air Quality

- Project design for prescribed fires and strategies for managing wildfires should incorporate as many emission reduction techniques as feasible, subject to economic, technical, safety criteria, and land management objectives.
- Decision documents, which define the objectives and document line officer approval of the strategies chosen for wildfires, should identify smoke sensitive receptors, and identify appropriate objectives and courses of action to minimize and mitigate impacts to those receptors.

Relevant Laws, Regulations, and Policies that Apply

The following list includes applicable laws, regulations, and policies affecting soils and watershed management on the KNF, the requirements of which are incorporated by reference herein.

The U.S. Forest Service Directives System (FSM/FSH): Forest Service Manuals and Handbooks codify the agency's policy, practice, and procedure. The system serves as the primary basis for the internal management and control of all programs and the primary source of administrative direction to Forest Service employees. The Forest Service Manual (FSM) contains legal authorities, objectives, policies, responsibilities, instructions, and guidance needed on a continuing basis by Forest Service line officers and primary staff in more than one unit to plan and execute assigned programs and activities. Forest Service Handbooks (FSH) are the principal

source of specialized guidance and instruction for carrying out the direction issued in the FSM. Specialists and technicians are the primary audience of Handbook direction. Handbooks may also incorporate external directives with related USDA and Forest Service directive supplements.

Forest Service Manual – Service Wide Issuance
Forest Service Manual 2500 – WATERSHED AND AIR MANAGEMENT

Region 3 (Southwestern Region): Regional Issuances
Forest Service Manual 2504.3 Exhibit 01
Forest Service Manual 2510 - WATERSHED PLANNING
Forest Service Manual 2520 - WATERSHED PROTECTION AND MANAGEMENT
Forest Service Manual 2530 - WATER RESOURCE MANAGEMENT
Forest Service Manual 2540 - WATER USES AND DEVELOPMENT
Forest Service Manual 2580 - AIR RESOURCE MANAGEMENT

Forest Service Handbook – Service Wide Issuance
Forest Service Handbook 2500 – Watershed and Air Management
Region 3 (Southwestern Region): Regional Issuances
2509.16 - Water Resource Inventory Handbook
2509.21 - National Forest System Water Rights Handbook
2509.22 - Soil and Water Conservation Handbook
2509.23 - Riparian Area Handbook
2509.24 - National Forest System Watershed Codes Handbook
2509.25 - Watershed Conservation Practices Handbook

The Organic Administration Act: (at 16 U.S.C. 475, 551). States the purpose of the national forests, and directs their control and administration to be in accord with such purpose, that is, "[n]o national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States." Authorizes the Secretary of Agriculture to "make such rules and regulations…to preserve the forests [of such reservations] from destruction."

Weeks Law of 1911: as amended (at 16 U.S.C. 515, 552). Authorizes the Secretary of Agriculture to enter into agreements with States for the purpose of conserving forests and water supply, and, to acquire forested, cutover, or denuded lands within the watersheds of navigable streams to protect the flow of these streams or for the production of timber, with the consent of the State in which the land lies.

Anderson-Mansfield Reforestation and Revegetation Joint Resolution Act of 1949 (at 16 U.S.C. 581j and 581j (note). States the policy of the Congress to accelerate and provide a continuing basis for the needed reforestation and revegetation of national forest lands and other lands under Forest Service administration or control, for the purpose of obtaining stated benefits (timber, forage, watershed protection, and benefits to local communities) from the national forests.

Granger-Thye Act of 1950 (16 U.S.C. at 580g-h). Authorizes the Secretary to use a portion of grazing fees for range improvement projects on NFS lands. Specific types of projects mentioned are artificial revegetation, including the collection or purchase of necessary seed and eradication of poisonous plants and noxious weeds, in order to protect or improve the future productivity of

the range. Section 11 of the act authorizes the use of funds for rangeland improvement projects outside of NFS lands under certain circumstances.

Sikes Act (Fish and Wildlife Conservation) of September 15, 1960 (16 U.S.C. at 670g). Section 201 directs the Secretary of Agriculture, in cooperation with State agencies, to plan, develop, maintain, coordinate, and implement programs for the conservation and rehabilitation of wildlife, fish and game species, including specific habitat improvement projects, and shall implement such projects on public land under their jurisdiction.

Soil and Water Resources Conservation Act of November 18, 1977 - Provides for a continuing appraisal of the United States' soil, water and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners and land users in furthering soil and water conservation.

Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528-531). States that the National Forests are to be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes, and that establishment and maintenance of wilderness areas are consistent with this Act. This Act directs the Secretary to manage these resources in the combination that will best meet the needs of the American people; providing for periodic adjustments in use to conform to changing needs and conditions; and harmonious and coordinated management of the resources without impairment of the productivity of the land. Sustained yield means achieving and maintaining in perpetuity a high-level annual or regular periodic output of renewable resources without impairment of the productivity of the land.

Watershed Protection and Flood Prevention Act of August 4, 1954 - Establishes policy that the Federal government should cooperate with states and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies for the purposes of preventing erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States; furthering the conservation, development, utilization, and disposal of water, and the conservation and utilization of land; and thereby preserving, protecting, and improving the Nation's land and water resources and the quality of the environment.

Water Quality Improvement Act of April 3, 1970 - Amends the prohibitions of oil discharges, authorizes the President to determine quantities of oil which would be harmful to the public health or welfare of the United States; to publish a National Contingency Plan to provide for coordinated action to minimize damage from oil discharges. Requires performance standards for marine sanitation device and authorizes demonstration projects to control acid or other mine pollution, and to control water pollution within the watersheds of the Great Lakes. Requires that applicants for Federal permits for activities involving discharges into navigable waters provide state certification that they will not violate applicable water quality standards

National Environmental Policy Act (NEPA) of 1969: (16 U.S.C. 4321 et seq.). Declares it is the policy of the Federal Government to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans. The Act requires agencies proposing major federal actions significantly affecting the quality of the human environment, to prepare a detailed statement on the environmental impacts of the proposed action, unavoidable adverse environmental impacts, alternatives to the action proposed, the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources which would be involved if the proposed action is implemented. The Act also provides that for any proposal which involves

unresolved conflicts concerning alternative uses of available resources, an agency must study, develop, and describe appropriate alternatives to recommended courses of action.

Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614, 472a). States that the development and administration of the renewable resources of the National Forest System are to be in full accord with the concepts for multiple use and sustained yield of products and services as set forth in the Multiple-Use Sustained-Yield Act of 1960. It sets forth the requirements for land and resource management plans for units of the National Forest System, including requiring guidelines to provide for the diversity of plant and animal communities based on the suitability and capability of the specific land area.

The Federal Water Pollution Control Act of 1972: Public Law 92-500, as amended in 1977 (Public Law 95-217) and 1987 (Public Law 100-4) (also known as the Federal Clean Water Act (CWA)): This Act provides the structure for regulating pollutant discharges to waters of the United States. The Act's objective is "…to restore and maintain the chemical, physical, and biological integrity of the Nation's waters," and is aimed at controlling both point and non-point sources of pollution. The U.S. EPA administers the Act, but many permitting, administrative, and enforcement functions are delegated to state governments. In Arizona, the designated agency for enforcement of the Clean Water Act is the Arizona Department of Environmental Quality (ADEQ).

Relevant sections of the Clean Water Act:

CWA Sections 208 and 319: recognizes the need for control strategies for non-point source pollution.

CWA Section 303(d): requires waterbodies with water quality determined to be either impaired (not fully meeting water quality standards for designated uses) or threatened (likely to violate standards in the near future) to be compiled by ADEQ in a separate list, which must be submitted to EPA every 2 years. These waters are targeted and scheduled for development of water quality improvement strategies on a priority basis.
Total Maximum Daily Loads (TMDLs): As of 2014, there are no applicable TMDL requirements in effect for the KNF.

CWA Section 305(b): requires that states assess the condition of their waters and produce a biennial report summarizing the findings.

CWA Section 401: allows states and tribes to review and approve, set conditions on, or deny Federal permits (such as 404 permits) that may result in a discharge to state or tribal waters, including wetlands. Applications for Section 404 permits are often joint 404/401permits to ensure compliance at both the Federal and state levels.

CWA Section 404: outlines the permitting process for dredging or discharging fill material into waters of the U.S., including wetlands. The U.S. Army Corps of Engineers administers the 404 Program.

Clean Air Act, as amended 1977 and 1990: (42 U.S.C. 7401, 7418, 7470. 7472, 7474, 7475, 7491, 7506, and 7602). Establishes a national goal to prevent any future, and remedy existing, visibility impairment in certain wilderness areas the Forest Service manages. It also directs the Forest Service as a Federal land manager to protect air quality related values from man-made air

pollution in these same areas. Lastly, it obligates the Forest Service to comply with the Act's many provisions regarding abatement of air pollution to the same extent as any private person.

North American Wetland Conservation Act of 1989 (16 U.S.C. 4401 (note), 4401-4413, 16 U.S.C. 669b (note)). Section 9 (U.S.C. 4408) directs Federal land managing agencies to cooperate with the Director of the U.S. Fish and Wildlife Service to restore, protect, and enhance the wetland ecosystems and other habitats for migratory birds, fish and wildlife within the lands and waters of each agency to the extent consistent with the mission of such agency and existing statutory authorities.

Executive Order 11988 (Floodplain Management (42 CFR 26951, May 25, 1977)**:** The purpose of this Order is "…to avoid to the extent possible the long and short term impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." Section 1 states: "Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands, and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities."

Executive Orders relevant to ecological restoration include:

Executive Order 11514: issued March 5, 1970, as amended by E.O. 11991 issued May 24, 1977. Protection and enhancement of environmental quality (35 FR 4247, March 7, 1970). This order states that the Federal Government shall provide leadership in protecting and enhancing the quality of the nation's environment to sustain and enrich human life. This order provides for monitoring, evaluation, and control on a continuing basis of the activities of each Federal agency so as to protect and enhance the quality of the environment.

Executive Order 11644: issued February 8, 1972. Use of off-road vehicles on the public lands. (37 FR 2877, February 9, 1972). Amended by E.O. 11989 issued May 24, 1977 and E.O. 12608 issued September 9, 1987. This order requires federal agencies to develop and implement procedures that will ensure that the use of off-road vehicles on public lands will be controlled and directed so as to protect the resources of those lands, to promote the safety of all users of those lands, and to minimize conflicts among the various uses of those lands.

Executive Order 11990 (Protection of Wetlands): …"in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands… Section 1. (a) *Each agency shall provide leadership and shall take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities* for…(3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. Sec. 5: In carrying out the activities described in Section I of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are: (b) maintenance of natural systems, including conservation and long-term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and

fiber resources; and (c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses."

Executive Order 13112 issued February 3, 1999. Invasive Species. (64 CFR 6183, February 8, 1999). This order requires federal agencies whose actions may affect the status of invasive species to, among other things, respond to and control populations of invasive species and provide for restoration of native species and habitat conditions in ecosystems that have been invaded by non-native invasive species.

Travel Management Rule: On December 9, 2005, the Forest Service published the TMR. The agency rewrote direction for motor vehicle use on National Forest Service (NFS) lands under 36 CFR, Parts 212, 251, and 261, and eliminated 36 CFR 295. The rule was written to address at least in part the issue of unmanaged recreation. The rule provides guidance to the Forest Service on how to designate and manage motorized recreation on the Forests. The rule requires each National Forest and Grassland to designate those roads, motorized trails, and Areas that are open to motor vehicle use.

Section 212.50 – "(a) Purpose. This subpart provides for a system of National Forest system roads, National Forest System trails, and areas on National Forest system lands that are designated for motor vehicle use. After these roads, trails, and areas are designated, motor vehicle use, including the class of vehicle and time of year, not in accordance with these designations is prohibited by 36 CFR 261.13. Motor vehicle use off designated roads and trails and outside designated areas is prohibited by 36 CFR 261.13.

Section 212.51 – "(a)…the following vehicles and uses are exempted from these designations:

(1) Limited administrative use by the Forest Service

(8) Motor vehicle use that is specifically authorized under a written authorization issued under Federal law or regulations.

(b) Motor vehicle use for dispersed camping or big game retrieval. In designating routes, the responsible official may include in the designation the limited use of motor vehicles within a specified distance of certain designated routes, and if appropriate within specified time periods, solely for the purposes of dispersed camping or retrieval of a downed big game animal by an individual who has legally taken that animal."

Section 212.52 – "(b) …Nothing in this section shall alter or limit the authority to implement temporary, emergency closures pursuant to 36 CFR part 261, subpart B, without advance public notice to provide short-term resource protection or to protect public health and safety.

(2) Temporary, emergency closures based on a determination of considerable adverse effects. If the responsible official determines that motor vehicle use on a National Forest System road or National Forest System trail or in an area on National Forest System lands is directly causing or will directly cause considerable adverse effects on public safety or soil, vegetation, wildlife, wildlife habitat, or cultural resources associated with that road, trail, or area, the responsible official shall immediately close that road, trail, or area to motor vehicle use until the official determines that such adverse effects have been mitigated or eliminated and that measures have been implemented to prevent future recurrence. The responsible official shall provide public notice of the closure…"

Section 212.54 –

"Designation of National Forest System roads, National Forest System trails, and areas on National Forest System lands pursuant to Section 212.51 may be revised as needed to meet changing conditions."

Section 212.55 – "(a) General criteria for designation of National Forest System roads, National Forest System trails, and areas on National Forest System lands… the responsible official shall consider effects on National Forest System natural and cultural resources..."

"(b) Specific criteria for designation of trails and areas. In addition to the criteria in paragraph (a) of this section, in designating National Forest System trails and areas on National Forest System lands, the responsible official shall consider effects on the following, with the objective of minimizing: (1) Damage to soil, watershed, vegetation, and other forest resources;…"

Section 212.57 – "For each administrative unit of the National Forest System, the responsible official shall monitor the effects of motor vehicle use on designated roads and trails and in designated areas…"

Road System: 36 CFR 212.5 (b):…the responsible official must identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands. ... The minimum system is the road system determined to be needed to meet resource and other management objectives adopted in the relevant land and resource management plan (36 CFR 219), to meet applicable statutory and regulatory requirements, to reflect long-term funding expectations, to ensure that the identified system minimizes adverse environmental impacts associated with road construction, reconstruction, decommissioning, and maintenance.

Regional Forester's direction: Roads analysis process (RAP) for all other existing roads should be completed in conjunction with implementation of the off-highway vehicle (OHV) Record of Decision, watershed analyses, other project level activities or Forest Plan revisions.

Identification of unneeded roads. Responsible officials must review the road system on each National Forest and Grassland and identify the roads on lands under Forest Service jurisdiction that are no longer needed to meet forest resource management objectives and that, therefore, should be decommissioned or considered for other uses, such as for trails.

Regional Forester's direction: Roads analysis process (RAP) for all other existing roads should be completed in conjunction with implementation of the off-highway vehicle (OHV) Record of Decision, watershed analyses, other project level activities or Forest Plan revisions.

Memorandum of Agreement on Fostering Collaboration and Efficiencies to Address Water Quality Impairments on National Forest System Lands: Agreement between U.S. Forest Service and the U.S. Environmental Protection Agency signed in 2007. Purpose: to coordinate between agencies and address issues of water quality impairment regarding 303d list, as well as TMDLs. The leading cause of water quality impairments on National Forest lands includes temperature, excess sediment, and habitat modification. These issues are to be addressed via BMPs to the greatest extent possible. In terms of this project analysis area, BMPs can be applied to soil and watershed condition and are applicable everywhere on the KNF.

36 CFR 219 Planning - Sets forth a process for developing, adopting, and revising land and resource management plans for the National Forest System.

40 CFR 121-135 Water Programs - Sets forth the provisions for the administration of water programs including: state certification of activities requiring a Federal license or permit; EPA administered permit programs; state program requirements; procedures for decision making; criteria and standards for the National Pollutant Discharge Elimination System; toxic pollutant effluent standards; water quality planning and management; water quality standards; water quality guidance for the Great Lakes System; secondary treatment regulation; and, prior notice of citizen suits. See Title 40 (Protection of Environment), Chapter 1 (Environmental Protection Agency), subchapter D (Water Programs).

40 CFR 1500 Council on Environmental Quality - Council on Environmental Quality regulations implementing the National Environmental Policy Act.

Arizona Administrative Code
Title 18 Environmental Quality
Chapter 9 – Water Pollution Control: This chapter pertains to aquifer protection permits, general permits, grazing Best Management Practices, use of recycled water, and Pollutant Discharge Elimination Systems.

Chapter 11 – Water Quality Standards: This chapter pertains to water quality standards for surface waters, reclaimed water quality standards, aquifer water quality standards, aquifer boundary and protected use classifications, and impaired water identification.

Resource Protection Measures

Resource protection measures listed below include references to the National Core BMPs found in the National Core BMP Technical Guide (FS-990a)(USDA, 2012), and SWCPs found in the Soil and Watershed Conservation Practices Handbook (FSH 2509.22)(USDA, 1990), and site-specific BMPs. Resource protection measures are implemented to minimize nonpoint source pollution as outlined in the intergovernmental agreement between the Arizona Department of Environmental Quality and the Southwestern Region of the Forest Service (ADEQ, 2013). Note that no resource protection measures are required for the No Action Alternative. Table 4 provides a summary of soil and watershed protection measures for the Burnt Corral Vegetation Management Project. During the planning phase of this project, it was determined that steep slopes (i.e., slopes greater than 40 percent) and sensitive soils within the project area should not be treated using heavy logging machinery do to the elevated risks of excessive soil disturbance and accelerated soil erosion.

Table 1. Resource protection measures required for Proposed Action.

Mitigation	Reference
Use applicable practices of BMP Plan-2 (Project Planning and Analysis) and BMP Plan-3 (Aquatic Management Zone [AMZ] Planning) when conducting planning and analysis.	FS-990a
Use suitable measures to avoid or minimize adverse effects to soil, water quality, or riparian resources when proposed operations	FS-990a

Mitigation	Reference
involve use of roads by traffic and during periods for which the road was not designed.	
Ensure that drainage features are fully functional on completion of operations.	FS-990a
Identify and evaluate road segments causing, or with the potential to cause, adverse effects to soil, water quality, and riparian resources.	FS-990a
Maintain the road surface drainage system to intercept, collect, and remove water from the road surface and surrounding slopes in a manner that reduces concentrated flow in ditches, culverts, and over fill slopes and road surfaces.	FS-990a
Maintain road surface treatments to stabilize the roadbed, reduce dust, and control erosion consistent with anticipated traffic and use.	FS-990a
Grade road surfaces only as necessary to meet the smoothness requirements of the assigned operational maintenance level and to provide adequate surface drainage.	FS-990a
Plan and locate surface water crossings to limit the number and extent to those that are necessary to provide the level of access needed to meet resource management objectives as described in the RMOs.	FS-990a
Design and locate landings of appropriate size and configuration to accommodate expected vehicle traffic and avoid or minimize adverse effects to soil and water quality.	FS-990a
Take advantage of existing openings, sites away from wet areas and waterbodies, and areas that are more easily restored to the extent practicable when identifying log landing locations.	FS-990a
Erosion control work is kept current. Construction of drainage facilities and performance of other work which will contribute to the control of erosion and sedimentation shall be carried out in conjunction with earthwork operations or as soon thereafter as practicable.	FSH 2509.22
Apply protective measures to all areas of disturbed, erosion-prone, unprotected ground that are not to be further disturbed in the present year.	FSH 2509.22
Culverts, coarse rock fills, hardened fords, low water crossings, and temporary bridges shall be designed to provide for unobstructed flows and to minimize damages to streamcourses.	FSH 2509.22

Mitigation	Reference
Do not blade roads when the road surface is too dry. If the road surface is too dry, apply water, or schedule road blading when adequate moisture is present to complete road reshaping.	N/A – site specific
On areas where prescribed fire is to be used, fire prescriptions should be designed to minimize soil temperatures to the greatest extent practicable. Fire prescriptions should be designed so that soil and fuel moisture and temperatures are such that soil burn severity is minimized and soil health and productivity are maintained.	N/A – site specific
On areas where prescribed fire is to be implemented, retain approximately 3-7 tons/acre of course woody debris in ponderosa pine stands to be left on-site after the prescribed burns.	N/A – site specific
On areas of prescribed fire use, if containment lines are installed, rehabilitate lines after use by implementing fireline BMPs. If firelines are only to be waterbarred, slash or disguise the first 300 feet of line from roadways or otherwise restrict motorized access to discourage use.	N/A – site specific
All fueling of vehicles will be done on a designated upland site. If more than 1,320 gallons of petroleum products are to be stored on site or if a single storage tank exceeds 660 gallons, then a spill prevention control and countermeasures (SPCC) plan will be prepared as per 40 CFR 112.	40 CFR 112 and site specific
Clean all equipment prior to entry on site with a high pressure washer to remove mud, debris, and vegetative material from the equipment. This prevents introduction of invasive or noxious weeds.	N/A – site specific
Clean all equipment prior to leaving the project area with a high pressure washer to remove mud, debris, and vegetative material from the equipment. This prevents transmission of invasive or noxious weeds to other sites if they were present in the project area. This also prevents mud and debris on roadways that could cause unsafe driving conditions.	N/A – site specific
Temporary access routes should not have long, straight runs down slopes that would re-direct or concentrate water flow. Such access routes should also be located out of filter strips, or AMZs (exceptions are at approved crossings).	N/A – site specific
Forest Service approved, certified weed-free native seed will be broadcast over disturbed areas such as decommissioned roads, log landings, skid trails, and pile burning areas to stabilize soils.	N/A – site specific

Mitigation	Reference
Seeding should only be conducted where there is insufficient woody debris to protect soil surfaces from erosion in order to minimize possible introduction of invasive plant species. Other acceptable erosion control measures include, but are not limited to, distributing slash and waterbarring (waterbars should not be more than two feet deep and require at least a ten foot lead out). Permanent water diversion structures are only to be installed using equipment with an articulating blade.	
Road drainage is controlled by a variety of methods including rolling the grade, insloping, outsloping, crowning, water spreading ditches (turnouts), and cross drainage. Sediment loads at drainage structures can be reduced by installing sediment filters such as rock and vegetative energy dissipaters, and settling basins.	N/A – site specific
Do not operate equipment when ground conditions are such that soil rutting, compaction or puddling can occur.	N/A – site specific
Treatment areas should be designed in a manner that minimizes soil disturbance and facilitates BMP implementation. TES maps should be reviewed for location of site specific BMP's in specified TES map units.	N/A – site specific
Activity generated slash from forest thinning are to be removed from stream courses and/or drainages. Trees are to be felled outside the stream courses and/or drainages and not across drainages.	N/A – site specific
Do not hand pile slash in designated stream courses or drainages, or other designated protected areas.	N/A – site specific
Ensure that existing drainage structures on roads (rolling dips, culverts, rock crossings, etc.) are functioning correctly.	N/A – site specific
Lead out ditches (turnouts) should be maintained in a manner that does not allow sediment-laden runoff to enter stream courses and/or drainages.	N/A – site specific
Adverse skidding (i.e., skidding upslope) should be avoided to the greatest extent practicable.	N/A – site specific
Machine piling of activity-related slash should be conducted with an excavator or track hoe with a bucket thumb rather than dozers to prevent soil being pushed into burn piles and minimize soil disturbance.	N/A – site specific

Mitigation	Reference
Harvesting contractors should not be permitted to proceed to subsequent pay units until all necessary soil stabilization measures are implemented.	N/A – site specific
Primary skid trails should not occur within 1 chain (66 feet) of Streamside Management Zones or run parallel to stream courses in these areas. Where this BMP cannot be strictly adhered to, alternative BMPs (use of slash mats and timing of operations during dry conditions) shall be employed.	N/A – site specific
Skidder crossings of ephemeral drainages should be minimized and designated in timber harvest area maps and on the ground	N/A – site specific
Designated skid trails and log landings will be required within the Timber Sale Contract on all cutting units. Skid trail design should not have long, straight runs that would direct water flow. Skid trails should also be located out of filter strips (exceptions are at approved crossings).	N/A – site specific
Felling to the lead will be required within the Timber Sale Contract (TSC) to minimize ground disturbance from skidding operations	N/A – site specific
On sites with impaired soils, do not use prescribed fire without prior approval of a soil and water specialist.	N/A – site specific
Use the following BMP techniques where needed to minimize sedimentation from road and trail construction and maintenance: Outsloped road surface; Leadout ditches and relief culverts; Energy dissipaters on culverts; revegetate cut and fill slopes; Riprap installation at stream crossings to protect water quality; Riprap or rock at intersections with paved public roads to prevent track-out of mud and debris Rolling grades.	N/A – site specific
Leadout ditches should not direct flow directly to ephemeral drainages or other water bodies, but should instead redirect runoff onto the undisturbed forest floor.	N/A – site specific
Culverts should be of adequate size to convey expected flows and properly installed.	N/A – site specific
After use, all temporary roads will be ripped to a shallow depth (<6"), seeded using the seed mix specified in BMP #10, drained through installation of necessary water diversion structures and covered with slash from landings.	N/A – site specific
Locate skid trails on-contour to the greatest extent possible. If cut and fill is required to establish serviceable trails, preferred drainage is outsloping of trail surfaces.	N/A – site specific

Mitigation	Reference
The logging and transportation system (i.e., the locations of temporary access roads, log landings and skid trails) are to be identified on the ground using flagging and on sale area maps. This planning BMP ensures that the transportation system is clearly identified in treatment areas and is understood by the logging contractor prior to use of heavy machinery on the ground.	N/A – site specific
Debris piles should be constructed using the rack-and-pile method. This will prevent damage to soil structure and loss of soil nutrients that result from pile burning and associated high soil burn severity.	N/A – site specific
Streamside management zones (SMZs), or Aquatic Management Zones (AMZs) will be identified on the ground using flagging and and on sale area maps.	N/A – site specific

Chapter 2. Alternatives, Including the Proposed Action

Introduction

This chapter describes and compares the alternatives considered for the Burnt Corral Vegetation Management Project. It includes a description of each alternative considered. This section also presents the alternatives in comparative form, sharply defining the differences between each alternative and providing a clear basis for choice among options by the decision maker and the public.

Alternatives

The Forest Service developed two alternatives, including the No Action and Proposed Action alternatives, in response to collaboration and any issues raised by the public. These alternatives are described in detail on pages 7-10 of the Proposed Action.

Comparison of Alternatives

This section provides a summary of the effects of implementing each alternative. Information in the table is focused on activities and effects where different levels of effects or outputs can be distinguished quantitatively or qualitatively among alternatives.

Table 2. Summary of effects to soils and watersheds for each alternative considered.

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
--- SOILS AND WATER QUALITY ---		
Soil disturbance / displacement	No new soil disturbance or displacement would occur	Approximately 15,070 acres are expected to exhibit some level of soil disturbance in the form of topsoil displacement and minor redistributions of surface soil horizons from mechanical equipment used to fell, bunch, skid, and land logs, fireline installation, and use of prescribed fire. These effects of these disturbances are generally of short duration and minor. Treated areas typically stabilize and revegetate within 1 to 3 years. Areal disturbance caused by tree harvesting typically ranges from 10 to 15 percent of treated areas, which would be within acceptable thresholds. Adverse disturbance would be minimized by implementation of Best Management Practices (BMPs) and Soil and Water Conservation Practices (SWCPs) as outlined in Table 1. This Alternative would achieve desired condition for soils and watershed over the long term by removing sufficient canopy cover to allow sunlight to penetrate to the forest floor, increasing the growth response of grasses, forbs and shrubs. Fine roots and vegetative ground cover provided by grasses and forbs can more effectively protect soils from erosion by wind and water than forest litter alone.
Soil erosion	No soil erosion above current, or background levels would occur. However, where forest ingrowth has resulted in dense stand conditions, vegetative ground cover has been replaced by litter (needles, twigs, bark,	Erosion potential is expected to increase on 10 to 15 percent of areas treated mechanically due to removal or displacement of ground cover. This erosion would be short term (1 to 5 years), localized, and mitigated

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
	limbs, etc.). These materials do not protect soils from erosion as effectively as grasses and forbs, which have fibrous root systems that more effectively anchor soils than litter cover alone.	with implementation of BMPs and SWCPs. Prescribed fire would increase erosion hazard where vegetative ground cover is insufficient for root crowns and unburned litter to protect soil surfaces from rain splash and wind erosion. Long term erosion potential on Terrestrial Ecosystem Survey (TES) map units currently in unsatisfactory condition would be reduced due to introduction of additional coarse woody debris (CWD) which increases surface roughness and decreases stormwater runoff velocities on soil surfaces in these map units. The increase in vegetative ground cover in treated areas would more effectively reduce erosion over the long term than litter alone through increased fine root biomass and associated exudates that increase soil aggregate stability.
Soil compaction	No additional areas of soil compaction would occur.	Approximately 3,000 acres are estimated to exhibit varying degrees of soil compaction, depending on the number and locations of skid trails, landings, and roads; timing of treatment activities, and types of machinery and manual treatments employed. Approximately 800 acres of temporary roads, 1,000 acres of skid trails, and 1,200 acres of landings are anticipated. Soil disturbance and compaction is typically most prevalent in landings. Skid trails usually have few to several passes, so are less disturbed than landings and temporary roads. Temporary roads typically exhibit minor rutting and compaction from log hauling. Minor, dispersed soil

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
		compaction would likely occur in areas where trees are mechanically felled and bunched prior to skidding. Higher levels of soil compaction typically occur in skid trails, landings, and roads rather than in areas where trees are felled and bunched due to multiple passes by machines and vehicles. Through implementation of BMPs and SWCPs described in Table 1, the areal extent of soil compaction can be minimized during mechanical treatments. Mitigation measures such as ripping, scarification or decompacting soils can mitigate these effects. Seeding increases root biomass and soil organic matter content, leading to natural amelioration of compaction over time. Freeze-thaw and wetting-drying cycles contribute to surface decompaction over time.
Soil Nutrient Cycling	No changes to soil nutrient cycling are anticipated.	Soil nutrient cycling would progress toward desired conditions as litter layers are replaced with vegetative cover where thinning treatments occur and low severity fire is reintroduced. Fine roots of grasses, forbs, and shrubs would improve soil aggregate stability, water infiltration, and decrease soil bulk densities. Reintroduction of low severity fire to this fire-adapted ecosystem would restore fire adaptation-related nutrient cycling processes including decomposition rates, and changes to litter types and quantities.
Slope Stability/landslides	There would be no changes to slope stability or increased risk of landslides as a result of the No Action alternative since there would be no disturbance that could lead to additional risk to slope stability.	Since steep slopes (i.e., greater that 40 percent) would not be treated mechanically, risk of slope instability from mechanical treatments is minimal. Prescribed fires on slopes greater than 40 percent pose only a slight risk to slope stability and this

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
	Since there would be no additional temporary roads under the No Action Alternative, there would be no additional risk of landslides as a result of concentration or redirection of ephemeral flows.	would only occur where high soil burn severity occurs over large areas. It is very unlikely that there be additional risk to slope stability as a result of mechanical or prescribed fire treatments in the project area. Temporary roads would be of a low design standard with few, if any areas where ephemeral flow would be concentrated or redirected. There would therefore be no additional risk of landslides caused by temporary roads.
Herbaceous ground cover	In the absence of fire, herbaceous ground cover would continue to decline as forest ingrowth and densification continues. The depth and areal extent of the soil litter layer would increase, thereby excluding the establishment and propagation of grasses and forbs.	Herbaceous ground cover would be greater than the No Action Alternative within one to five years following thinning treatments since more open stand structures contribute to understory development through increased soil moisture and improved organic matter content due to introduction of coarse and fine woody debris. Low severity prescribed fire would reduce herbaceous ground cover for short timeframes (i.e., 1 to 2 years), but root crowns would remain intact and most grasses and forbs would respond with vigorous growth.
Soil CWD component	TES map units that do not currently have adequate CWD would exhibit a gradual increase in CWD over a long period of time through tree mortality and decadence. However, these TES map units would not benefit from the introduction of CWD that would occur rapidly through vegetation treatments as described in the proposed action.	Vegetation treatments would increase CWD in unsatisfactory TES units, improving nutrient stores and protecting soil surfaces from erosion by wind and water. On TES map units that currently have excess CWD, prescribed burning or piling followed by pile burning or use of prescribed fire would bring CWD levels to desired conditions of 5 to 7 tons per acre.

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	**2 Proposed Action**
	TES map units that currently have excessive CWD (i.e., greater than 7 tons per acre) would continue to be at elevated risk of high severity wildfire in the absence of treatments to control fuel loads.	
Soil heating and water repellency (hydrophobic conditions)	There would be no soil heating or additional soil water repellency (hydrophobic conditions) under the No Action Alternative. However, conditions would be conducive to increased hazard of high severity wildfire that would result in large areas of hydrophobic soils that would be prone to erosion and sediment delivery to ephemeral and intermittent drainages.	Areas where pile burning is conducted, and some areas where prescribed fire is implemented would exhibit hydrophobic soil conditions and damage to soil structure caused by rapid oxidation of soil minerals and organic matter. The occurrence of these conditions would depend primarily on the timing, duration, type (i.e., prescribed or managed wildfire), and intensity of fire. In general hydrophobic soils and soils damaged by extreme heating are expected to be localized and relatively minor. Application of BMPs, particularly rack-and-pile technique, would minimize damage to soil resources caused by soil heating. Vegetation treatments would produce more open stand conditions, including canopy gaps that would reduce fire intensity and therefore soil burn severity and minimize areas of hydrophobic soils. The greatest risk of increased areas of hydrophobic soils would be where prescribed burning is conducted prior to forest thinning or wildfire is managed in areas where no forest thinning has occurred. Over the long term, these treatments would reduce the risk of high

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
		severity wildfire and associated adverse impacts to soils.
Soil Organisms	No changes to soil organism populations would be introduced as a result of this project under the No Action Alternative.	Soil organism populations are expected to decline for short periods (1 to 3 years) in areas where soil disturbance or soil compaction occur and where fire is introduced. Soil organism populations are expected to recover rapidly under this alternative as greater sunlight would reach the forest floor, increasing soil biological activity.
Water quality	There would be no changes to surface water quality as a result of this project under the No Action Alternative.	There are no perennial streams in the project area, so effects to water quality would occur on a storm event or runoff basis. Short term, localized effects to water quality are possible, but it is very unlikely these effects would be detectable in downstream intermittent or perennial streams. As vegetative ground cover increases in treated areas, water quality in ephemeral drainages would improve due to reduced sediment delivery to drainages.
Water yield	There would be no changes to water yield as a result of this project under the No Action Alternative	Since only a small percentage of each 6th-level watershed (HUC) is being treated, only minor increases in water yield are expected. Within the project area, increased soil moisture and groundwater recharge can be expected as tree basal area is reduced. However, as herbaceous vegetation increases, any increase in near-surface groundwater would likely be uptaken by trees, grasses and forbs.
Watershed condition	Watershed conditions would continue to decline under the No Action Alternative. This is due to fire regime condition classes (FRCC) that further deviate from the FRCC historic range of variation. Surface litter	Watershed condition would be improved as the FRCC would be returned to the historic, or natural range of variation. Natural ignitions (i.e., wildfires) would generally result in lower soil burn severities. Increased vegetative ground cover

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
	and fuel loads would continue to increase, resulting in greater risk of uncharacteristic wildfire and higher soil burn severities. Where natural ignitions occur, the resulting higher burn severities would increase sediment delivery to streamcourses, increase channel incision (downcutting) and aggradation, scour and bank failure. Surface water quality would also be compromised.	would reduce soil particle detachment and transport to drainages. Surface water quality would be improved as sediment-laden runoff would be reduced.
Air quality	This alternative proposes the least amount of thinning and prescribed fire to move vegetation towards desired conditions. The estimated outcome is greater forest density and higher proportions of closed canopy conditions with a corresponding lower likelihood of future surface fire behavior and associated reduced particulate emissions. Thinning and prescribed fire treatments would continue to occur at current rates. Planned ignitions would be coordinated with the Arizona Department of Environmental Quality, as well as with adjacent agencies, to ensure that exceedances of State or Federal emissions standards do not result.	Focused application of thinning and prescribed fire to move vegetation towards desired conditions increases the percentage of open states in ponderosa pine dominated communities. Future fire behavior is expected to produce the lowest particulate emissions among the alternatives. Planned ignitions would be coordinated with the Arizona Department of Environmental Quality, as well as with adjacent agencies, to ensure that exceedances of State or Federal emissions standards do not result.
Nuisance smoke	Prescribed fire use would occur as it has in the past. Nuisance smoke impacts would therefore be about the same as they have been whenever a prescribed fire is implemented. The areal extent of nuisance smoke impacts and the number of people affected would depend on a variety of factors such as	The Burnt Corral Project is not in a National Ambient Air Quality Standards (NAAQS) non-attainment area. There are no urban areas or major highways in close proximity to the project area. While smoke from prescribed fire may pose a nuisance to forest visitors in the vicinity of the Burnt Corral Project or those recreating in drainages below the

Resource and Unit of Measure	ALTERNATIVES	
	1 No Action	2 Proposed Action
	the amount of fuels consumed by the fire, weather patterns and their effect on smoke dispersal, the number of people recreating in the area during or after the prescribed fire treatment and the status of visitor's respiratory condition.	project after a prescribed fire has been implemented, nuisance smoke impacts are not expected to extend to large areas or adversely affect a large number of people.

Chapter 3. Affected Environment and Environmental Consequences

This section details the affected environment and environmental consequences for the soils, water, and air resources within the analysis area. It establishes the baseline against which the decision maker and the public can evaluate the effects of the action alternative.

This section also describes the direct, indirect, and cumulative effects of implementing each alternative (No Action Alternative and Proposed Action) on the soil, water, watershed and air resources in the project area. It presents the scientific and analytical basis for the comparison of the alternatives presented in Alternatives section. NEPA requires consideration of "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR 1502.16). As declared by the Congress, this includes using all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (NEPA Section 101).

Affected Environment

Soils

Elevations within the project area range from 6,800 feet above mean sea level (amsl) near Pine Hollow Trick Tank in the northwest to 8,096 feet amsl near Road Hollow Tank in the southeast. Slopes range from nearly flat (less than 5 percent) to 65 percent with steeper slopes generally occurring along canyons of the western and southern portions of the project area.

Soil Condition

Soil condition is defined as an evaluation of soil quality based on an interpretation of factors which effect vital soil functions (USDA Forest Service, 1999). Soil condition is normally determined by evaluating surface properties of the A horizon and the status of erosion (Brewer et al., 1991). The surface soil layer (A horizon) varies in thickness and is generally distributed evenly across the soil surface. The A horizon is where plant and animal organic matter

accumulates and begins to decompose and is eventually incorporated into the mineral soil. It is also the zone of maximum biological activity and nutrient releases. The physical condition of this organically enriched A horizon plays a significant role in soil stability, nutrient cycling, energy flows and recovery mechanisms, and atmospheric carbon sequestration. The condition of the A horizon greatly influences how rapidly water infiltrates into the soil (National Research Council, 1994).

Organic matter in its various forms contributes to soil productivity. Humus is decomposed organic matter while duff, or litter, consists of relatively undecomposed or partially decomposed leaves, needles, and twigs that are still recognizable on the surface of soils. Coarse woody debris (CWD) consists of woody stems greater than 3 inches in diameter. Decomposing coarse woody debris can supply moisture to plants and animals after soils have dried. All organic matter provides water and nutrients for soil organisms and plants. Because CWD is an important component of a functioning ecosystem, a portion of this material must be maintained (Graham et al. 1994). However, excessive accumulations of woody debris can result in high intensity fires, resulting in large losses of soil organic matter (Harvey 1994). Currently, most soils within the project area exhibit an abundance of organic matter in a variety of size classes.

Knowledge of specific fungal, bacterial, and arthropod populations is not available for analysis in this project. Biological soil crusts, commonly found in arid or semi-arid environments (USDA NRCS 1997) are not known to exist in the activity areas. However, cryptogamic crusts have been identified in virtually every ecosystem in Grand Canyon National Park, from the mixed conifer forests and pinyon-juniper woodlands to the shrub deserts (Beymer and Klopatek 1992). During their study, Beymer and Klopatek also observed cryptogamic crusts at two locations in the Tusayan Ranger District of the Kaibab National Forest near the National Park boundary. It is reasonable to expect that biological soil crusts would occur within the proposed treatment areas.

In arid and semi-arid native plant communities, plants often exhibit patchy distributions that result in discontinuous fuel conditions that result in a mosaics of fire intensities (Whisenant 1990). Biological soil crusts do not provide adequate fuel to carry a fire through interspaces, thereby serving as "refugia" to decrease the spread of fire and its intensity (Rosentreter 1986). The remaining unburned islands of vascular vegetation and biological soil crust provide propagules for reestablishment in burned areas. Johansen et al. (1993) observed that the structural matrix of soil biological crusts remained intact following low-intensity fire, indicating that lightly burned crusts still function to provide stability against erosive forces.

Populations of other soil organisms include mycorrhizal fungi, soil-dwelling arthropods, nematodes and bacteria. Some loss of soil organisms would likely occur in the short-term through direct destruction of habitats or substrates during tree felling, broadcast prescribed burning, pile burning, and fuelwood gathering. It is expected that areas where such losses occur would re-populate and soil chemical, physical and biological conditions would improve over time.

There are approximately 1,415 acres of soils that are in unsatisfactory condition due to erosion rates that are exceeding tolerance thresholds. These soils generally exhibit less organic matter and vegetative ground cover than required to maintain soil productivity and prevent soil loss. Approximately 965 acres of unsatisfactory soils within the project area are found within the Bridger Knoll Fire burned area. These include map units 271 (521 acres) and 274 (444 acres).

Table 3. Terrestrial Ecosystem Survey (TES) soil map units located in the Burnt Corral project area and their associated acreages.

MAP UNIT SYMBOL	SOIL TAXONOMIC CLASSIFICATION	SOIL PHASE	ACRES
005	Pachic Udic Argiudolls	Deep loam	83.0
009	Cumulic Haploborolls	Deep loam	125.3
037	Aquic Haploborolls	Deep gravelly very fine sandy loam	44.0
252	Lithic Ustochrepts	Gravelly fine sandy loam	183.1
271	Lithic Ustochrepts	Gravelly loam	965.2
273	Typic Haplustalfs	Gravelly loam	564.4
274	Typic Ustochrepts	Gravelly fine sandy loam	450.1
293	Mollic Eutroboralfs	Loam	11,880.8
294	Mollic Eutroboralfs	Loam	7,081.8
297	Mollic Eutroboralfs	Gravelly loam	1,154.5
298	Mollic Eutroboralfs	Gravelly loam	921.7
299	Typic Haploborolls	Moderately deep gravelly loam	480.2
620	Lithic Haploborolls	Gravelly loam	533.7
621	Mollic Eutroboralfs	Moderately deep very cobbly loam	538.5
622	Lithic Haploborolls	Gravelly fine sandy loam	8.1
623	Typic Paleboralfs	Gravelly sandy loam	29.9
624	Eutric Glossoboralfs	Gravelly sandy loam	2,335.5
625	Eutric Glossoboralfs	Cobbly loam	73.5
672	Typic Haplustalfs	Gravelly loam	118.9
673	Typic Haplustalfs	Gravelly loam	557.8
Total			28,086.1

Soil Erosion Hazard

The TES defines erosion hazard based on bare ground (complete removal of vegetation and litter). A slight rating indicates that all vegetative ground cover could be removed from the site and the resulting soil loss will not exceed "tolerance" soil loss rates. A moderate rate indicates that predicted rates of soil loss will result in a reduction of site productivity *if left unchecked*. Conditions in moderate erosion hazard sites are such that reasonable and economically feasible mitigation measures can be applied to reduce or eliminate soil loss. A severe rating indicates that predicted rates of soil loss have a high probability of reducing site productivity before mitigation measures can be applied. Within the analysis area, there are about 13,244 acres of soils having slight erosion hazard, about 9,251 acres of soils having moderate erosion hazard, and about 5,592 acres of soils having severe erosion hazard (Table 4).

Table 4. Soil conditions, erosion hazard ratings, slope ranges and modeled erosion rates for forest thinning and prescribed fire on TES map units in the Burnt Corral project area. Highlighted map would not receive mechanical thinning treatments.

MAP UNIT	SOIL CONDITION	EROSION HAZARD	SLOPE	MODELED EROSION T/AC/YR	TOLERANCE EROSION T/AC/YR	ACRES
005	Satisfactory	Slight	0-5	0.02	2.7	83.0
009	Satisfactory	Slight	0-15	0.04	2.7	125.3
252	Satisfactory	Severe	40-80	0.14	2.7	44.0
271	Unsatisfactory	Severe	40-80	0.13	1.8	183.1
273	Satisfactory	Moderate	15-40	0.08	2.7	965.2
274	Unsatisfactory	Severe	40-120	0.15	2.7	564.4
293	Satisfactory	Slight	0-15	0.04	2.7	450.1
294	Satisfactory	Moderate	15-40	0.08	2.7	11,880.8
297	Satisfactory	Slight	0-15	0.04	2.7	7,081.8
298	Satisfactory	Moderate	15-40	0.06	2.7	1,154.5
299	Satisfactory	Severe	40-80	0.14	2.7	921.7
620	Satisfactory	Moderate	15-40	0.08	1.8	480.2
621	Satisfactory	Severe	15-40	0.10	1.8	533.7
622	Satisfactory	Moderate	0-15	0.06	1.8	538.5
623	Satisfactory	Moderate	0-15	0.06	2.7	8.1
624	Satisfactory	Severe	15-40	0.10	2.7	29.9
625	Satisfactory	Severe	40-120	0.15	2.7	2,335.5
672	Satisfactory	Moderate	0-15	0.06	2.7	73.5
673	Satisfactory	Severe	15-40	0.10	2.7	118.9

Watersheds

The Burnt Corral Project occurs in six HUC12 subwatersheds. Table 5 below provides a summary of watershed condition ratings, acres within the project area, and total watershed acres.

Table 5. Subwatersheds (HUC12) in the Burnt Corral Project, their current condition ratings, total watershed acres, and total acres within the project area

WATERSHED NAME	HYDROLOGIC UNIT CODE (HUC12)	CONDITION RATING	TOTAL WATERSHED ACRES	PROJECT AREA ACRES	PERCENT
Castle Canyon	150100030701	Functional at risk	11,168.7	0.7	0.006
Indian Hollow	150100031002	Impaired	32,672.6	3,986.4	12.2
Jumpup Canyon	150100031003	Functional at risk	36,877.2	5,987.1	16.2
Lookout Lakes	150100030702	Impaired	38,718.6	3,108.3	8.03
Nail Canyon	150100030705	Impaired	17,600.9	1.2	0.006
Sowats Canyon	150100031001	Impaired	39,565.0	15,002.5	37.9
Total			**176,603.0**	**28,086.2**	

Table 6 below provides a summary of the reasons for watershed condition ratings found in Table 5. Appendix B provides a summary by watershed of indicator ratings that resulted in the corresponding watershed condition rating found in Table 5.

Table 6. Summary of subwatershed condition ratings.

WATERSHED NAME	REASON FOR CONDITION RATING
Castle Canyon	Reduced flows to springs and riparian areas; high road density; infrequent road maintenance; private septic systems present
Indian Hollow	Low road maintenance; many stock tanks present
Jumpup Canyon	Fire regime departed from reference condition; high road density; infrequent road maintenance; cinder pits and septic systems present; many stock tanks; 3 water wells and 2 reservoirs present.
Lookout Lakes	Reduced flows to springs and riparian areas; high road density; infrequent road maintenance; many roads near water courses; cinder pits present; many stock tanks, 1 well, and 4 reservoirs present.
Nail Canyon	Infrequent road maintenance; many stock tanks present.
Sowats Canyon	Unsatisfactory soils in watershed; reduced flows to springs and riparian areas; high road density; infrequent road maintenance

Water Quality and Quantity

Section 305(b) of the Clean Water Act requires states to assess and report on the water quality status of waters within the states. Section 303(d) requires states to list waters that are not attaining water quality standards. This is also known as the list of impaired waters. This information is reported to Congress on a nationwide basis. Arizona Department of Environmental Quality is responsible for conducting monitoring, assessment, reporting under CWA Sections 303(d) and 305(b), and TMDL development for the State of Arizona.

Arizona's most recent Integrated Report (305(b) Water Quality Assessment and 303(d) list) is available from the Arizona Department of Environmental Quality (ADEQ). The Arizona Impaired Waters List can be found at: http://legacy.azdeq.gov/environ/water/assessment/

There are no perennial running waters within the project area; there is therefore no surface water quality data for the project area. No water bodies within the project area or on the North Kaibab Ranger District are listed as impaired on the Arizona 2012/2014 Impaired Waters List.

There are no intermittent or perennial streams within the project area. Stream channels in this area exhibit only ephemeral flow characteristics. Streamflow only occurs for brief periods of time as a result of spring snowmelt and monsoon precipitation. Streamflow and runoff volumes within the project area are not monitored. There are no streamflow data for ephemeral channels within the project area. Typically, ephemeral drainages in the project areas exhibit bimodal seasonal flow patterns – typically during spring snowmelt and following localized, high intensity summer monsoon precipitation

Air Quality

The Clean Air Act establishes National Ambient Air Quality Standards (NAAQS) for six principal pollutants that pose health hazards: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter less than 10 microns in size (PM-10), particulate matter less than 2.5 microns in size (PM-2.5), ozone (O_3), and sulfur dioxide (SO_2). The major pollutant of concern in smoke from wildland fire for both planned and unplanned ignitions is fine particulate matter

(Ottmar 2001), although other pollutants such as carbon monoxide, aldehydes, and hundreds of other compounds emitted by wildland fires are found in very low concentrations at short distances away from a fire. Particles larger than 10 microns in size tend to settle out of the air; smaller particles remain airborne, and can cause respiratory problems. Ward and Hardy (1984) measured a large difference in emission factors for particles of the respirable size range (PM-2.5) as compared to particles without regard to size (PM). This difference increased proportionally to an increase in the rate of heat release on an area basis. They noted a slight decrease in emission factors for PM2.5 with an increase in PM emission factors over the range of rates of heat release tested (Ward and Hardy 1991). Human health studies on the effects of particulate matter indicate that it is PM-2.5 that is largely responsible for health effects (Dockery and others 1993). Because of its small size, PM-2.5 has an especially long residence time in the atmosphere and penetrates deeply into the lungs (Ottmar 2001) and are therefore defined as the respirable fraction. The Clean Air Act defines the NAAQS for PM-2.5 as an annual mean of 15μg/m^3, and a 24 hour average of 35μg/m^3. At this concentration or above, PM-2.5 has an adverse effects on human health.

Coarse particles about 5 to 10 microns in diameter (PM10) can deposit in the upper respiratory system. Fine particles less than 2.5 microns in diameter (PM 2.5) can penetrate much deeper into the lungs. Typically wildland fire events result in relatively short-term smoke exposures (hours or days). It is important to understand that it is not simply the total emissions from fire affect human health, but rather how concentrated pollutants in ambient air are over a period of time. Atmospheric conditions during a fire can strongly influence how particulate matter is distributed through ambient air, and its potential to affect public health. Wind speed, wind direction, mixing layer height, atmospheric temperature profile upward in the atmosphere, and atmospheric stability all effect where and how well smoke will disperse.

With precautions that reduce smoke exposure such as limiting outside exertion during smoke events, healthy individuals may not suffer serious long-term effects although temporary minor irritation may result when particulate matter concentrations are elevated. The effects of breathing wildland fire smoke include eye and throat irritation, shortness of breath, headaches, dizziness, and nausea.

Regional haze is air pollution that is transported long distances and affects large geographic areas. It can cause reduced visibility in national parks and wilderness areas. The same particulate matter that causes risks to public health is also largely responsible for impairments to visibility. "The combination of light absorption by elemental carbon and light scattering caused by the very small particles that make up wildland fire smoke explains why emissions from wildland fire play such an important role in visibility impairment" (Core 2001).

The project area is not located adjacent to large population centers, power plants, or industrial facilities. The closest coal-fired power plant to the project area is the Cholla Power Plant near Holbrook, Arizona. The project area is located approximately 155 miles west-northwest of the Cholla Power Plant. The prevailing southwest winds on most days of the year carry pollution from these plant away from the North Kaibab Ranger District. It is unlikely that either of these power plants are causing adverse air quality impacts in the project area. The project area is located approximately 60 aerial miles east of Las Vegas, Nevada, 198 aerial miles north of Phoenix, Arizona, and 329 miles from Los Angeles, California. Pollution and haze from these and other urban/industrial centers has potential to adversely affect air quality in the project area. Visibility is sometimes affected by haze from these cities, but effects are minor. Wildfires and

prescribed fires occasionally contribute smoke, particulates, and haze to the project area. Windblown, or fugitive dust during periods of high wind can cause localized effects to air quality. The North Kaibab Ranger District is not located within an air quality Non-Attainment Area designated by the Arizona Department of Environmental Quality (ADEQ). The closest Non-Attainment Areas are Las Vegas (CO, PM-10, and 8-Hour Ozone and Bullhead City Area for PM-10 (particulate matter) and the Phoenix Area for PM 10 and ozone.

The Regional Haze Rule (40 CFR 51.309(d)(7)) requires states to assess and reduce pollutants that cause haze in order to improve visibility at Class I Areas, including Grand Canyon National Park. The Regional Haze State Implementation Plan for the State of Arizona dated February 28, 2011 states "The Commission's technical assessment indicated that road dust is a large contributor to visibility impairment on the Colorado Plateau. As such, it requires urgent attention. However, due to considerable skepticism regarding the modeled contribution of road dust to visibility impairment, the Commission recommended further study in order to resolve the uncertainties regarding both near-field and distant effects of road dust, prior to taking remedial action. Since this emissions source is potentially such a significant contributor, the Commission felt that it deserved high priority attention and, if warranted, additional emissions management actions. Road dust is not a measurable contributor on a regional level to visibility impairment in the 16 Class I areas. Due to this finding, no additional road dust control strategies are needed…" The Plan also states that the State of Arizona will "perform further assessments of road dust impacts on visibility. Based on these assessments, if road dust emissions are determined to be a significant contributor to visibility impairment, the State of Arizona commits to implement emissions management strategies…".

The Kaibab National Forest must submit prescribed burn plans to ADEQ for approval in order to minimize the effects of smoke, but it is not required to reduce fugitive dust or vehicle emissions at this time.

The majority of roads on in the project area are unpaved. These gravel and native surface roads are sources of fugitive dust in dry weather, especially when there is frequent vehicle traffic. Vehicles driving cross country may also create fugitive dust. Fugitive dust impacts to air quality are generally localized and short term.

Environmental Consequences

Direct and Indirect Effects

Direct effects of an action are caused by the action and occur on site and affect only the area where they occur. Indirect effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. In general, direct and indirect effects to soils, watershed condition and air quality as a result of the Proposed Action include:

- Reduction of the forest canopy would decrease interception (precipitation captured by leaves, branches, and boles) and increases net precipitation reaching the soil surface.
- Partial removal of the forest overstory reduces transpiration (water lost from plants to the atmosphere).
- Reductions in interception and transpiration increase soil moisture content, water available for plant uptake, and water yield.
- Increased soil moisture and loss of root biomass can reduce slope stability.

- Increases in water yield after forest thinning are transitory and decrease over time as forests regrow unless subsequent treatments maintain initial post-treatment conditions.
- When young, dense forests with high interception rates (or higher annual transpiration losses) replace mature forests with lower interception rates (or lower transpiration losses); water yield is reduced until the young forest matures and thins naturally or is thinned in treatments.
- Impervious surfaces (roads and trails) and altered hillslope contours (cutslopes and fillslopes) modify water flowpaths, increase overland flow, and deliver overland flow directly to stream channels.
- Impervious native surfaces increase soil erosion.
- Altered hillslope contours and modified water flowpaths along roads increase risk of landslides.
- Particulate emissions form prescribed and managed fires that could adversely affect human health.
- Dust from roads could affect visibility and adversely affect human health
- Nuisance smoke

Table 2 provides a comparative summary of direct and indirect effects to soils and water quality by Alternative for the Burnt Corral Project.

No Action Alternative

There would be no direct effects to soils and water quality as a result of the no action alternative. However, in the absence of fire, indirect effects include herbaceous ground cover that would continue to decline as forest ingrowth and densification continues. The depth and areal extent of the soil litter layer would increase, thereby excluding the establishment and propagation of grasses and forbs. TES map units would not benefit from the introduction of CWD that would occur rapidly through vegetation treatments as described in the proposed action.

Watershed conditions would continue to decline under the No Action Alternative. This is due to FRCC that further deviate from the FRCC historic range of variation. Surface litter and fuel loads would continue to increase, resulting in greater risk of uncharacteristic wildfire and higher soil burn severities. Where natural ignitions occur, the resulting higher burn severities would increase sediment delivery to streamcourses, increase channel incision (downcutting) and aggradation, scour and bank failure. Surface water quality would also be compromised. Conditions would be conducive to increased hazard of high severity wildfire that would result in large areas of hydrophobic soils that would be prone to erosion and sediment delivery to ephemeral and intermittent drainages.

Proposed Action Alternative

Potential adverse effects of the Proposed Action on soil productivity would include soil compaction, puddling, displacement, erosion, areas of high soil burn severity, loss of soil organic matter, short-term changes in soil moisture content, changes in nutrient cycles, and changes in soil fauna. These effects can result from mechanical and non-mechanical vegetation treatments (i.e., forest thinning and prescribed fire), mechanical and non-mechanical piling of activity-related debris, fireline installation, and temporary road construction, maintenance, and decommissioning activities. Mechanical forest vegetation treatments has the potential to adversely affect water quality through introduction of sediment and additional nutrients from decomposing woody debris, particularly in thinned areas adjacent to stream courses. Implementation of BMPs and SWCPs as specified in Table 1 would minimize adverse impacts to soils and water quality from these activities.

Soil compaction, puddling and displacement would primarily be limited to the transportation systems and high traffic areas within mechanical vegetation treatments such as existing National Forest System roads, temporary access roads, skid trails, log landings, debris piling areas, and areas where fireline construction occur. Road closures and curtailment of mechanical vegetation treatments during wet weather conditions and designation of authorized access routes (skid trails and temporary roads) and log landing locations within the project area prior to project implementation would minimize adverse effects to soil productivity caused by these activities. With implementation of applicable BMPs and SWCPs as outlined in Table 1, most adverse effects to soils would be minimized or mitigated. Additionally, seasonal wetting and drying, freezing and thawing, and soil organism activity would naturally ameliorate some adverse effects to soils caused by the Proposed Action.

The effects of the proposed forest restoration activities on erosion and sediment yields depend on methods and equipment used, skills of the equipment operators and personnel conducting the treatments, site-specific conditions, storm event timing and intensity, and prescribed fire locations and burn severities. Table 4 provides modeled erosion rates for each TES map unit in the Burnt Corral project area. As can been seen in Table 4, soil erosion rates from the combined effects of forest thinning and prescribed fire would not exceed tolerance erosion rates for any of the TES map units in the project area.

The risk of short-term accelerated soil erosion would be expected to increase in areas where forest thinning and use of prescribed fire results in extensive soil disturbance or complete removal of vegetative ground cover. These areas are expected to include skid trails, log landings, temporary access roads, decommissioned temporary roads, installed firelines and National Forest System roads.

The removal of forest cover can decrease raindrop interception and evapotranspiration, which can increase water yields from treated areas (Bosch and Hewlett 1982, Stednick 1996). In areas where the annual precipitation is less than 20 in (500 mm), removal of the forest canopy does not typically increase annual water yields (Bosch and Hewlett 1982). In drier areas, such as the proposed project site, the decrease in interception and transpiration caused by forest thinning is usually offset by the increase in soil evaporative losses, resulting in no net change in runoff as long as factors affecting runoff processes are not changed (for example, soil compaction which causes a shift from subsurface flow to overland flow) (MacDonald and Stednick 2003). Evapotranspiration rapidly recovers with vegetative regrowth in partially thinned forests. Increases in runoff due to thinning operations rarely persist for more than 5 to 10 years, unless maintenance treatments are implemented.

Thinning of forest cover on soils currently characterized as unsatisfactory would improve soil conditions over the long-term by improving soil moisture and allowing greater sunlight penetration to the forest floor (i.e., sunflecks) resulting in an increase in grasses, forbs and shrubs in the forest understory. The increased woody debris and herbaceous vegetation would reduce soil erosion rates by providing vegetative and litter ground cover that would intercept rain before it can reach soil surfaces and detach and entrain soil particles in runoff. Woody debris from forest thinning (i.e., slash) would be lopped and scattered where doing so would not result in excessive fuel loads and increased wildfire risk, further mitigating potential adverse effects to these soils. Fine woody debris that is incidental to forest vegetation treatments (i.e., needles, leaves, twigs, cones, bark, etc.) would also remain on the ground following mechanical treatments to protect soil surfaces from wind and water erosion.

Prescribed fire that would occur as a result of project activities has the potential to impact water quality by increasing sediment yields, dissolved solids, and nutrients in runoff. Dissolved nutrients in stream flow primarily originate from weathering of parent materials and soils, decomposition of plant material and other organic matter, and anthropogenic sources. Vegetative communities accumulate and cycle nutrients (Tiedemann et al. 1979, 1980). Fire can disrupt nutrient cycling and cause nutrient volatilization, leaching, and transformations. When vegetation is consumed by fire, some of the soil and organic matter nutrients such as nitrogen, phosphorus, copper, iron, manganese, and zinc are volatilized and lost from the system, while other nutrients such as calcium, magnesium, and potassium are converted into oxides and accumulated in ash (DeBano et al. 1998).

The mobility and concentration of nutrients in soils determines whether or not nearby water sources are at risk of contamination when prescribed fire is used. Nitrate is highly mobile and is therefore subject to risk of being leached from burned areas and transported to either surface or ground water. Phosphorus adsorbs readily to sediment and organic materials. Thus, phosphorus is usually transported to streams and water bodies through soil erosion. Rates of soil erosion and phosphorus contamination are generally dependent on soil characteristics and topographic relief of the site.

Prescribed fire has the potential to alter short- and long-term soil productivity and moisture content by changing the amount and type of vegetation, the amount of forest floor organic matter, and surface soil texture and wettability. Prescribed fires typically leave greater amounts of organic matter (duff, forest litter, and large and small woody debris) on soil surfaces than uncontrolled fires. These materials serve as nutrient sinks, prevent soil particle detachment caused by raindrop impact, and capture sediments that would otherwise be transported to stream channels and waterbodies. Following low-severity prescribed fires, an increase in grasses and other herbaceous vegetation often occurs. This rapid regrowth of ground cover further immobilizes nutrients in plant material.

Prescribed fires that remove large amounts vegetation from a site have potential to alter watershed hydrology. As vegetation is removed, evapotranspiration in the watershed decreases, thus providing greater stream flow and overall water yield within the watershed. Water uptake from trees is species-specific. Conifers, which are the dominant vegetation type within the Burnt Corral Project area, generally transpire greater quantities of water than hardwoods such as oaks and aspen. Dense foliage and longer growing seasons promote the higher overall water uptake in conifers. Additionally, conifers have relatively dense crowns that intercept rainfall and allow for greater evaporative losses.

Once a site has undergone loss of vegetation and removal of the litter layer, surface runoff can cause increased erosion and greater stream discharges. Fires not only consume portions of the litter layer, but at high temperatures fires can also cause hydrophobic soil conditions, thus making soils more susceptible to erosion. DeBano and Krammes (1966) and Robichaud (2000) observed that water repellency was dependent on the heating temperatures of the soils. At typical wildfire soil profile temperatures (less than 500°F) when the soil was dry, soil hydrophobicity occurs at shallow depths (less than 1 inch). When soils are moist (i.e. conditions that commonly occur during prescribed fire in the spring and fall), soil hydrophobicity was less pronounced and only occurred after long heating times which would typically only occur during smoldering fires. Therefore, soil hydrophobicity under a prescribed fire scenario would likely be minimal throughout the majority of the project area.

Fire in southwestern ponderosa pine forests has been shown to generally increase soil moisture content (Ryan and Covington 1986, Ower 1985, Haase 1986). In a review of literature, Hungerford and others (1991) reported that burning can kill many kinds of bacteria, fungi and arthropods but the extent of this effect is dependent on the amount of heat generated by the fire and soil moisture content. To what extent these changes result in an impairment or degradation of soil productivity is not clearly understood. Hungerford suggests that low to moderate intensity prescribed fires may have minimal long-term negative effect on soil microorganisms. Kaye and Hart (1998) found that microbial nitrogen transformation rates increased under restored forest conditions, relative to the controls, suggesting higher microbial activity in the restored areas. Neary and others (1999) caution against the adverse effects to soil microorganisms caused by fires that become intense or are too frequent. Researchers have recommended maintaining soil carbon pools to maintain biologic activity (Stark and Hart, 1997), and recommend maintaining heterogeneity in burned areas to provide suitable sites from which the microflora and microfauna can reestablish in burned areas (Moldenke, 1999). Prescribed fires under the Proposed Action are expected to be of low severity with small areas of medium and high severity, retaining unburned islands and creating a mosaic of fire effects. Low and medium severity fires burn only a portion of the surface organic matter – leaving adequate soil cover over much of the burned area to protect soil surfaces. In general, low severity prescribed fire does not cause excessive erosion or sediment transport since soil cover is retained in a discontinuous pattern across the landscape. This type of prescribed fire would not have a long-term adverse impact on soil moisture content or biota. The increase in understory vegetation as a result of implementing this project would improve long term soil structure and porosity through increased fine root volume and vegetative litter, which are important habitat components for soil fauna that then incorporate organic matter into soil profiles and facilitate nutrient cycling.

Installation of firelines where they do not currently exist would expose soil surfaces, increasing the risk of erosion by both wind and rain. Rehabilitation of firelines following prescribed burning would minimize adverse impacts to soil productivity from fireline installation.

Areas of high severity fire may consume forest floor organic matter, leaving soils hydrophobic (i.e., repellant to water) and susceptible to erosion. Implementing prescribed burning under conditions that would minimize high severity fire would minimize areas where soil organic matter is totally consumed and prevent hydrophobic soil conditions. Initially, the greatest risk of soil erosion would most likely occur in areas where prescribed fire is implemented prior to forest thinning treatments. This is due to greater amounts of woody debris on the ground and higher stand and crown densities at these locations, which increases the risk of high severity fire.

Piling of activity-related debris (slash) would disturb soil surfaces, exposing them to direct raindrop impact and wind. On steep terrain this would increase localized, short-term erosion rates in areas where piling of woody debris is conducted. Additionally, use of excavators with hydraulic bucket thumb attachments rather than dozers would minimize soil disturbance during machine piling.

Burning of slash piles has been shown to negatively affect soil biotic and chemical properties due to intense soil heating (Korb et al, 2004 and Seymour and Tecle, 2004). It can result in soil sterilization, increased erosion risk and an increased risk of invasive and noxious weeds that displace native vegetation. Pile burning sites would constitute a small portion of the project area (i.e., less than 5 percent). However, the damage to soil chemical and physical properties from burning of debris piles can persist on the landscape for many years. Use of applicable BMPs and SWCPs as outlined in Table 1, including use of the rack-and-pile method would mitigate most

adverse effects from piling of woody debris and burning of this material after forest thinning. Monitoring of debris pile burning sites for the presence of invasive or noxious weeds following pile burning, and treatment of any infestations found would mitigate most adverse effects to soils caused by pile burning of slash.

Soil organic matter serves as the long-term nutrient supply for all vegetation occupying a site. It also provides microhabitat for most soil organisms and improves soil chemical and physical properties including soil aggregate stability, increased porosity and water holding capacity, lower bulk densities, and improved nutrient cycling. Initially, there would be an expected short-term increase in soil organic matter as a result of mechanical vegetation treatments as woody debris is deposited on soil surfaces during treatments. Forest thinning would also allow greater light penetration to soil surfaces resulting in warmer soil temperatures. The reduction in tree vegetative cover as a result of forest thinning would decrease evapotranspiration rates and therefore increase soil moisture. Warmer soil temperatures and greater soil moisture content would result in increased soil biological activity. Increased soil biological activity results in a proportional decrease in soil organic matter as organisms consume soil detritus. The eventual increase in understory vegetation would result in increased litterfall and deposition of organic matter onto soil surfaces. Broadcast prescribed fire would result in rapid oxidation of surface organic matter and living understory biomass, causing a release or transformation of some soil nutrients.

Runoff from road surfaces can detach and entrain fine material from road prisms and ditches. Sediment delivery directly from road surfaces to water courses is difficult to estimate since it occurs as part of non-point source runoff. Sediments delivered to streams from roadside ditches may have originated from sheet or rill erosion prior to entering road surfaces or drainage ditches. In the absence of vehicle traffic, sediment concentrations in road runoff decreases over time. However, vehicle traffic, particularly trucks, can pulverize road surface aggregates, resulting in more fine particles that are easily transported in runoff. Additionally, the pressure of vehicular tires on saturated road surfaces can force fine particles from below the surface to move upward to the surface (Truebe and Evans 1994).

Road proximity and connectivity to drainages can strongly influence sediment delivery to watercourses and peak flows in streams. Roads within the project area intersect numerous ephemeral drainages. These points of intersection occur as both culverted crossings and low-water crossings. Road-stream intersections are the primary location where sediments are delivered to stream courses. Implementation of BMPs and SWCP as described in Table 1 would minimize or mitigate adverse effects to soil productivity and water quality from road use and maintenance and temporary road construction, use and decommissioning. With implementation of the BMPs and SWCPs outlined in Table 1, and with monitoring to assure proper implementation and effectiveness of BMPs and SWCPs, soil erosion thresholds would not be exceeded and there would be no long term adverse effects to water quality.

Cumulative Effects

No Action Alternative

No direct effects would occur as the result of the no action alternative, thus no cumulative effects are anticipated. However, as described in the indirect effects section, in the absence of fire, herbaceous ground cover would continue to decline as forest ingrowth and densification

continues. The depth and areal extent of the soil litter layer would increase across the, thereby excluding the establishment and propagation of grasses and forbs. TES map units would not benefit from the introduction of CWD that would occur rapidly through vegetation treatments as described in the proposed action.

Watershed conditions would continue to decline under the No Action Alternative. Where natural ignitions occur, the resulting higher burn severities would increase sediment delivery to streamcourses, increase channel incision (downcutting) and aggradation, scour and bank failure. Surface water quality would also be compromised. Conditions would be conducive to increased hazard of high severity wildfire that would result in large areas of hydrophobic soils that would be prone to erosion and sediment delivery to ephemeral and intermittent drainages. Cumulatively, exclusion of fire in the project area could have negative effects to soil and water resources across the cumulative effects area.

Proposed Action Alternative

Cumulative effects include the impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other action (40 CFR § 1508.7). The geographic setting for the cumulative effects analysis for soils and watersheds includes all of the 6th-level (HUC12) hydrologic unit watersheds where the Burnt Corral Restoration Project is located, which comprises approximate 176,603 acres. The timeframe for past actions is 10 years, based on soil productivity, vegetative response, and coarse woody debris recovery within treated areas. Surface disturbing activities that are older than 20 years are assumed to be contributing negligible or no measurable cumulative effect within the analysis area. The timeframe for future actions is 20 years, based on implementation for other projects within the cumulative effects area.

Following is a listing of actions considered in the cumulative effects analysis for this project:

- Activities such as vegetation management, fuels management, livestock grazing, recreational activities, and other management activities (e.g. noxious weeds treatments) have occurred in the past, are occurring, and are reasonably foreseeable actions on the North Kaibab Ranger District.
- Firewood cutting has occurred in the past and would likely continue in the foreseeable future on the District within watersheds that include the project area.
- Road maintenance, reconstruction, or decommissioning may occur with future vegetation management projects on National Forest System land.
- Recreation activities are expected to continue to increase on the Forest. Future recreation projects may be developed.

Specific past, present and foreseeable future actions include:

- Plateau Facilities Fire Protection Project (PFFPP)
- Jacob-Ryan Project
- Moquitch Habitat Improvement Project
- Burnt Saddle Pine Hollow and Lookout timber sales
- Salvage logging in the Bridger Fire
- Westlake Project
- Big Saddle Project

- Kaibab Plateau Ecological Restoration Project (KPERP)

The Plateau Facilities Fire Protection Project (PFFPP) and Jacob-Ryan project are in the vicinity of Jacob Lake. These two project areas encompass approximately 30,000 acres and would include similar activities as the Burnt Corral Restoration Project. Activities include mechanical thinning (precommercial thinning and commercial timber sales) on approximately 20,000 acres and use of prescribed fire on approximately 25,000 acres. These actions would improve forest health with reduce fire hazard and potential soil burn severity. Soils and watershed conditions would therefore be improved across the cumulative effects area following these activities as more robust understory vegetation begins to occupy sites currently dominated by litter. By reducing the risk of high soil burn severity, the risk of cumulative adverse effects to soils, watersheds, and water quality such as erosion and sediment delivery to drainages would be reduced.

The Moquitch Habitat Improvement Project would improve forest health, wildlife habitat, and reduce fire hazard on 10,000 acres in the ponderosa pine forest cover type and would occur east of Forest Road 462 and north of Forest Road 212, extending to the southern portion of the Jacob-Ryan Project. Approximately 75 percent of planned prescribed fire have been completed in this project area. Improved soils and watershed function are already being realized as a result of this project and when added to the effects of this project would cumulatively improve soil and watershed function. The understory of grasses and forbs has improved, thereby contributing to greater soil stability than litter alone. Reduced stand densities has resulted in a corresponding reduction in the risk to soils, watershed function and water quality by reducing the potential for high soil burn severity. In combination with the Burnt Corral Project, there would be a positive cumulative effect to soils and water resources through increased spatial extent of forest conditions that are conducive to low severity fire and therefore improved soil stability and watershed condition, improved watershed function, and protection of water quality.

Past timber sales in the Burnt Corral area include Burnt Saddle, Pine Hollow, and Lookout. The primary benefits of these projects are improved surface fuel continuity which promotes low intensity surface fire, more open stand structures, and effective fuel breaks. These treatments encompass approximately 9,620 acres, which include even-aged regeneration treatments that have established young forest. Intermediate thinning treatments were completed across approximately 85 percent of the acres that were commercial timber sales. The cumulative effects from these past management activities include forest openings that are large enough to prevent active crown fires. These projects, in conjunction with the proposed action would cumulatively improve soil health by preventing high soil burn severity that would increase soil erosion rates. Reducing soil erosion rates improves surface water quality and watershed function.

Salvage logging and reforestation occurred on approximately 1,360 acres in the Bridger Fire burned area. The cumulative effects of these activities include establishment of new forest cover in the form of advanced regeneration, and a future source of ponderosa pine seed within the burned area. This potential future timber and the associated seed crop would be protected from both managed and unmanaged wildfires. Salvage logging removes fuels that can contribute to high soil burn severity under both prescribed fire or wildfire conditions. Soil disturbance resulting from salvage logging did not result in long term adverse effects to soils or watershed resources as exemplified by forest regeneration and increased vegetative ground cover, which has contributed to increased soil stability in most areas where salvage logging was conducted. There has been no direct adverse cumulative effect to soils or watershed resources from salvage logging. A positive cumulative effect of salvage logging is the reduced risk of reburn of dead trees within some areas

of the Warm Fire where salvage logging has occurred. Cumulatively, sufficient CWD remains to provide beneficial nutrient cycles and soil recovery over time.

The Westlake project included approximately 1,130 acres of ponderosa pine forest thinning and hand-piling of woody debris. This project was primarily thinning of small conifers from 2' to 8.9" diameter at breast height (dbh). The resulting woody debris was hand-piled until 2009, and the piles were burned. This treatment reduced the density of small trees, thereby reducing ladder fuels that can contribute to canopy fires. There is opportunity for future commercial timber sales in the Westlake Project area during Burnt Corral project implementation. The cumulative effect of the Westlake project in conjunction with the Burnt Corral project is reduced risk for high severity wildfire that could adversely affect soils and watershed resources.

The Big Saddle thinning and lopping project is immediately adjacent to the southwest boundary of the Burnt Corral Project. This area is approximately 565 acres in size. Ponderosa pine trees from 2 to 8.9 inches dbh were removed. Wildfire hazard has therefore been reduced in this area and forest productivity improved. The reduced wildfire hazard and increased soil organic matter content through lopping and scattering of woody debris has improved soil condition. The additional organic matter provides for improved nutrient cycling, carbon sequestration and increased surface cover and roughness, which prevents soil erosion and sediment delivery to drainages. The overall effects of this project in combination with the Burnt Corral project is improved soils and watershed condition and protection of surface water quality.

The Kaibab Plateau Ecological Restoration Project (KPERP) is approximately 518,000 acres and encompasses most of the North Kaibab Ranger District of the Kaibab National Forest. The project proposes approximately 319,000 acres of prescribed fire supported by approximately 122,000 acres of noncommercial mechanical and hand treatments. The goal is to use prescribed fire at a frequency that would restore fire resilience to the landscape. This project would improve forest and watershed health while reducing fire hazard. In combination with the Burnt Corral Project, there would be a positive cumulative effect to soils and water resources through increased spatial extent of forest conditions that are conducive to low severity fire and therefore improved soil stability and watershed condition, improved watershed function, and protection of water quality.

All of the projects described above cumulatively contribute to improved forest health and reduced fire hazard. Cumulative effects from projects within the cumulative effects analysis area including Burnt Corral would not contribute to soil loss rates above tolerance thresholds. Cumulative effects from temporary roads across all projects within the cumulative effects analysis area would be negligible and short-term since temporary road construction, use and decommissioning would be mitigated through BMPs. The cumulative effects to soils and watershed resources, water quality and air quality would include: a) improved soils health through increased herbaceous vegetative ground cover that prevents erosion and sediment delivery, b) improved nutrient storage and release, c) reduced sediment delivery to drainages, d) improved air quality due to reduced fuels that could otherwise burn for prolonged periods and create large amounts of smoke in an uncontrolled fire.

By moving the Burnt Corral area to a more resilient and fire-adapted ecosystem, and reducing tree density and associated fuel loads to more historic conditions, the risk of stand-replacing wildfire that has profound adverse effects to soils, water quality and watershed condition would be reduced considerably.

Unavoidable Adverse Effects

Unavoidable adverse effects resulting from Proposed Action include: a) construction and use of temporary roads, b) minor erosion and potential ephemeral channel elongation headward from prescribed fire, c) smoke from prescribed fires, and d) localized soil compaction and removal of vegetative ground cover. While these adverse effects cannot be avoided, they can be mitigated or minimized to acceptable levels that are within tolerance thresholds through implementation of BMPs and SWCPs described in Table 1.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be regained, such as the extinction of a species or the removal of mined ore. Irretrievable commitments are those that are lost for a period of time such as the temporary loss of timber productivity in forested areas that are kept clear for use as a power line rights-of-way or road.

There are no irreversible or irretrievable commitments of resources as a result of the Proposed Action.

Air Quality

Evaluation of cumulative effects from smoke on air quality differs from the evaluation of cumulative effects for many other resources; this is due to the transient nature of air quality impacts from smoke. It is a relatively simple exercise to estimate the total tons per acres of emissions from planned ignitions in the Burnt Corral project area, and other adjacent land management agencies, but there is no calculation that correlates total annual emissions to total concentrations of emissions. Impacts are measured as concentrations of emissions, whether it's in $\mu g/m^3$ for NAAQS, or in deciviews measuring visibility in Class I Areas. Cumulative effects are not the total emissions produced in a day or a year, but rather the concentration of all fire emissions in a given airshed at a given time. For NAAQS these concentrations have a varying time weighted period depending on the pollutant. For PM_{10} and $PM_{2.5}$, they are measured as a 24 hour average, and as an annual arithmetic mean.

Cumulative effects from planned and unplanned ignitions that are not being actively suppressed on Federal, State, and Tribal lands, are largely mitigated through implementation of the Enhanced Smoke Management Program, in the Arizona State Implementation Plan (SIP), by the Smoke Management Group. When the Federal land managers actively began prescribed fire programs in the 1970s, they became rapidly aware that smoke does not respond to artificial boundaries or delineations, and that a pro-active program for the coordination of prescribed fires would be vital to obtain and continue support of prescribed fire programs by ADEQ and the public. An interagency Smoke Management Group was developed in partnership with the State, and housed in the ADEQ offices in Phoenix. The personnel in the group are funded largely by the Federal agencies, demonstrating the initiative of the agencies to, in some degree, self-regulate emissions production from prescribed fires, across Federal and State boundaries.
This group assists Arizona land managers in not exceeding NAAQS or visibility thresholds through the following services:

- Serves as a central collection point for all prescribed fire requests from the numerous Federal, State, and Tribal land managers who are all competing to produce smoke that will impact the same airsheds during limited windows of opportunity.
- Evaluates potential emissions from individual and multiple, and determines how meteorological forecasts will affect smoke concentrations both during the burn, and during diurnal settling. The Group considers cross-boundary impacts; and weighs burning decisions against possible health, visibility, and nuisance effects.

- Assists in coordinating activities within and between agencies when potential emissions would likely exceed desired conditions.
- Makes recommendations on the approval or disapproval of each prescribed fire request to ADEQ officials.
- Tracks the use of Best Management Practices and Emission Reduction Techniques used by land managers, to document efforts by land managers to minimize impacts to Air Quality. This information is used promote support from both ADEQ and the public.
- Monitors data gathered from the IMPROVE network to assess visibility impacts in Class I areas, and track progress towards Arizona SIP goals.

While emissions from wildfires are not regulated, Federal, State, and Tribal land managers understand their responsibility to balance the ecological benefits of wildfires with the social impacts of the smoke they produce. The Smoke Management Group also assists land managers in this area through:

- Limiting prescribed fire approvals during periods when wildfires are already impacting an airshed.
- Making recommendations on the timing, or assisting in the coordination between units, of tactical operations such as burn outs, that will produce large amounts of emissions, so that they are done, when possible, when ventilation conditions are most favorable, or spread out over several burning periods to reduce total emissions when ventilation is not as good.
- Assisting land managers in determining the strategy to take on new wildfires. There may be enough fires burning that suppression on a new start is recommended to reduce cumulative smoke impacts even though all other fire effects would be desirable, and move the fire area towards desired conditions as stated in the Land Management Plan.
- Acting as a sounding board for public complaints. In keeping tabs on the type and number of complaints, the Group is able to provide land managers feedback from beyond their local publics on the state of public smoke tolerance. This is vital in maintaining general public support of allowing wildfires to perform their natural role in the ecosystem under the right circumstances in future windows of opportunity.

Through the services of the Smoke Management Group, cumulative effects from wildland fire that are within the control of Federal and State Land Managers, are thus managed to keep air quality across Arizona within desired conditions, including not exceeding NAAQS, protecting visibility in Class I Areas, and additionally promoting general public support of wildland fire management programs.

Climate

While it is currently not possible to discern climate change effects of the Proposed Action, given the lack of effects that can be meaningfully evaluated under current science and modeling, one would expect a very minor, initial, short-term increase in atmospheric CO_2 and other greenhouse gases from the proposed treatments through burning of hydrocarbons to conduct mechanical vegetation treatments, rapid oxidation of vegetation and woody debris during prescribed burning, and increased decomposition of woody debris. However, long-term effects would be positive as the ground cover of grasses and forbs increases. Woody debris would provide long-term nutrient sources and contribute to surface roughness, decreasing potential erosion. Nutrients released in ash during prescribed burning and through decomposition of residual woody debris from forest thinning would also improve soil quality. As previously noted the increase in ground cover of grasses, forbs, and shrubs, which have higher fine root turnover rates than large woody plants

would result in greater soil organic matter content over time. Soils within the project area would therefore sequester more CO_2 over the long term.

The U.S. Environmental Protection Agency (EPA) has asserted that scientists know with virtual certainty that human activities are changing the composition of the Earth's atmosphere. It is also documented that "greenhouse" gases, including CO_2, methane (CH_4), nitrous oxide (N_2O), and hydro fluorocarbons have been increasing (EPA, 2010). The atmospheric increase of these gases is largely the result of human activities such as the burning of fossil fuels. Greenhouse gases absorb infrared energy that would otherwise be reflected from the earth. As this infrared energy is absorbed, the air surrounding the earth is heated (CARB 2007).

The Southwestern Region of the Forest Service recently released "Southwestern Region Climate Change – Trends and Forest Planning: A guide for addressing climate change in forest planning on southwestern National Forests and Grasslands. The following information is summarized from excerpts of this publication:

In the Southwest, climate modelers agree there is a drying trend that will continue well into the latter part of 21st century (IPCC 2007; Seager et al. 2008). Climate modelers predict increased precipitation, but believe that the overall balance between precipitation and evaporation would still likely result in an overall decrease in available moisture. Regional drying and warming trends have occurred twice during the 20th century (1930s Dust Bowl, and the 1950s Southwest Drought). Current drought conditions "may very well become the new climatology of the American Southwest within a time frame of years to decades". According to recent model results, the slight warming trend observed during the last 100 years in the Southwest may continue into the next century, with the greatest warming to occur during winter. Climate models predict temperatures to rise approximately 5 to 8 degrees Fahrenheit by the end of the century (IPCC 2007). This trend would likely increase demand on the region's already limited water supplies, as well as increase energy demand, alter fire regimes and ecosystems, create risks for human health, and affect agriculture (Sprigg et al. 2000).

Average ambient air temperatures are rising, and it is possible that continued warming will increase the temperature difference between the Southwest and the tropical Pacific Ocean, enhancing the strength of westerly winds that carry moist air from the tropics into the Southwest region during the monsoon season. This scenario may increase the monsoon's intensity, or its duration, or both, in which case floods would occur with greater frequency (Guido 2008). While the region is generally expected to dry, it is possible that extreme weather patterns leading to more frequent destructive flooding would occur. Along with monsoons of higher intensity, hurricanes and other tropical depressions are projected to become more intense overall. Arizona typically receives 10 percent or more of the annual precipitation from storms that begin as tropical depressions in the Pacific Ocean. In fact, some of the largest floods in the Southwest have occurred when remnant tropical storms intersect frontal storms from the north or northwest (Guido 2008). Most global climate models are not yet accurate enough to apply to land management at the ecoregional or National Forest scale. This limits regional and forest-specific analysis of the potential effects of climate change.

Due to the spatial and temporal limitations of climate models, as stated above, site-specific analysis of climate change at the Forest level with regard to implementing fuels reduction treatments remains impractical. Several unknown factors further limit discussion and analysis of climate change at the Forest level. These include: lack of data on emissions from prescribed fire and wildfires, lack of data on emissions from logging machinery and traffic increases due to transportation of logs to processing facilities, limited data on emissions from machinery used to

construct or maintain roads, and limited knowledge of the contributions of surrounding areas to current and future climate impacts at the Forest level necessary to analyze cumulative effects.

Projected future climate change could affect Arizona in a variety of ways. Public health and safety could be compromised due to an increase in extreme temperatures and severe weather events. Agriculture would be vulnerable to altered temperature and rainfall patterns, increasing plant stress and susceptibility to insects and diseases. Forest ecosystems could face increased occurrences of high severity wildfires and may be more susceptible to insects and diseases. Snowpack could decrease and snowmelt may occur earlier.

While the future of climate change and its effects across the Southwest remains uncertain, it is certain that climate variability will continue to occur throughout the region. Forest management activities should strive to promote ecosystem resilience and resistance to impacts of climate change. Forest management activities should focus on maintenance and restoration of native ecosystems, thereby reducing the vulnerability of these ecosystems to variations in climate patterns. Ecological diversity remains an integral component in native ecosystems. Projects should promote connected landscapes and endeavor to restore significantly altered biological communities, thus restoring their resilience to changes in climate. This projects promotes restoration of native ecosystems, returns fire to fire-adapted ecosystems, improves vegetative ground cover, and increases soil productivity and carbon sequestration cabability of soils. For these reasons, this project ot only increases the resilience of forested ecosystems within the project area to the effects of climate change, but decreases the risk of climate change by decreasing atmospheric CO_2 through improved carbon sequestration in soils and reduction of emissions from high severity fire.

No Action

The No Action Alternative would result in no forest restoration treatments in the project area in the immediate future. Therefore, there would be no direct effects to soils, water quality, ephemeral or intermittent stream channels, watershed condition, or changes to water yield as a result of the no-action alternative. However, land management activities and changing vegetative conditions throughout the last 100 years have produced an uncharacteristic accumulation of fuels and increased trees density within the project area. These conditions make wildfire a possibility and suppression difficult.

A high-severity wildfire is not certain to occur within the project area during any given timeframe. However, the occurrence of a high-severity wildfire would have an increased potential for profound adverse impacts to hydrologic systems in project area watersheds and downstream locations. As previously discussed in this report, such a fire event would likely result in increased runoff and potential for soil erosion and sediment delivery to ephemeral streams as a result of loss of forest interception of rainfall, reduced soil water infiltration rates, and the reduction of effective ground cover at the soil surface. The infrequent nature of ephemeral stream flow results in the potential for sediment and ash to be stored within these stream channels and then transported during surface runoff events. This, in turn, could pose detrimental effects to surface water quality.

Other potential detrimental effects to hydrologic conditions in the project area and downstream locations could include the destabilization of the geomorphic conditions of stream channels due to excessive sediment delivery and debris loading, increased peak flows, and overall increases in average annual water yield resulting from loss of upslope interception, infiltration, and evapotranspiration. Ephemeral stream channels within high burn severity areas would lose their

ability to buffer runoff from large rainfall events, resulting in increased channel scour and incision caused by accelerated runoff and erosion from severely burned watershed areas. Increased bedloads in stream channels effectively raises the elevation of stream bottoms, causing flood flows to exceed channel capacities, resulting in overland flooding. These conditions could result in increased flooding risk in downstream locations.

Another effect is sediment and ash deposition in downstream landscape positions, including roads and livestock and wildlife waters, even if these areas may not have burned. In addition, sediment and ash-laden overland flows may damage low lying roads by eroding road traveled ways and filling culverts and low water crossings with sediment and debris. These are examples of why post-wildfire watershed conditions are significantly different from pre-fire or low-severity prescribed fire conditions

Recommendations

In order to ensure that desired conditions are achieved and remain consistent with the KNF Forest Plan, monitoring of soil disturbance caused by timber harvesting and use of prescribed fire is advised. Best Management Practices (BMP) implementation monitoring and soil disturbance monitoring should be conducted following treatment activities in order to ensure proper implementation of BMPs to prevent soil erosion and delivery of sediment and other pollutants to waterbodies. A recommended soil and watershed monitoring plan is summarized below.

Phase 1 – During Timber Harvest Activities
The timber sale administrator will monitor the implementation of BMP's during timber harvesting activities. Notes taken by the timber sale administrator will be used to track any issues or problems with BMP implementation. The Forest Soils and Watershed Specialists will provide assistance as needed by the timber sale administrator to provide clarification of BMP's specified in the Environmental Impact Statement (EIS).

Phase 2 – Timber Sale Closure
The timber sale administrator will verify that the timber sale purchaser has implemented all erosion control measures prior to the closure of the timber sale. Primary responsibility will be that of the timber sale administrator with final review by the Forest Soils and Watershed Specialists.

Phase 3 – Broadcast and Pile Burning
The District Fire Management Officers will verify that all erosion control measures associated with all burning activities has been implemented. Final reviews will be conducted by the Forest Soils and Watershed Specialist.

Phase 4 – Effectiveness Monitoring
Within the first year following timber sale closure, BMP's are evaluated for effectiveness. Monitoring will concentrate on such items as erosion control measures for skid trails, log landing or decking areas, road maintenance, road closure/decommissioning, and burned areas. The Forest Soils and Watershed Specialists will conduct a soil condition evaluation within treatment units. The focus of evaluations will be on such items as vegetative ground cover, coarse woody debris, soils erosion, soil compaction, and soil displacement. All monitoring results should be documented. Primary responsibility is with the District Ranger and the Forest Soils and Watershed Specialists.

Phase 5 – Follow Up
Documented information obtained from monitoring is used to adjust BMP's as necessary, to improve implementation and effectiveness of BMP's. Information regarding monitoring results and recommended changes to BMP's will be made available to the Arizona Department of Environmental Quality (ADEQ) for review as specified in the Intergovernmental Agreement between the State of Arizona and U.S Department of Agriculture, Forest Service Southwestern Region. Primary responsibility is with the District Ranger and the Forest Soils and Watershed Specialists.

Certification

Kit MacDonald prepared the report considering the Best Available Science and locally gathered data. A majority of the effects of fire on soil and water attributes were attained through research review, including RMRS GTR-42, volume 4 *Wildland Fire in Ecosystems Effects of Fire on Soil and Water* (Neary et al, 2005). Local data include the *Terrestrial Ecosystems Survey of the Kaibab National Forest* (Brewer et al, 1991) and relevant geospatial data.

My experience includes a Master's Degree in Forestry with an emphasis in Soil Science and completion of coursework toward a Ph.D. in Forestry from Stephen F. Austin State University. Since 1999, I have worked in areas of soils classification and mapping, wetland delineation and functional assessment, wetland restoration, disturbed land remediation and reclamation, and forestry best management practices (BMP) implementation and effectiveness monitoring related to silvicultural operations including timber harvesting, site preparation, reforestation, and forest road construction and decommissioning, and air quality monitoring.

Prepared by: /s/ *Kit MacDonald* Date: May 18, 2018

Kit MacDonald
Soils and Watershed Program Manager
Coconino and Kaibab National Forests

And

Micah Kiesow Date: November 20, 2019
Forest Soil Scientist
Kaibab National Forest

References

Arizona Department of Environmental Quality. 2013. Memorandum of Understanding between the State of Arizona Department of Environmental Quality and the USDA, Forest Service Southwestern Region. Signed May 2013.

Bosch, J.M.; Hewlett, J.D. 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology. 55: 3-23.

Brewer, David G., Rodney K. Jorgensen, Lewis P. Munk, Wayne A. Robbie, and Janet L. Travis. 1991. Terrestrial Ecosystem Survey of the Kaibab National Forest, Coconino County and Part of Yavapai County. USDA Forest Service. 319 pp.

Core, J. E. 2001. Visibility Smoke Management Guide for Prescribed and Wildland Fire 2001 Edition. NWCG. PMS 420-2, NFES 1279. Boise, ID.

CARB, 2007. California Air Resources Board. California EPA Air Resources Board Accessed. March 4, 2016

DeBano, L. F. and Krammes, J. S. 1966. Water repellent soils and their relation to wildfire temperatures. Bulletin of the I.A.S.H., XI(2):14- 19.

Debano, L. F.; Neary, D.G.; Ffolliot, P.F. 1998. Fire's effects on ecosystems. New York: John Wiley and Sons, Inc. 333 p.

Dockery D.W., C.A. Pope 3rd, X. Xu, J.D. Spengler, J.H. Ware, M.E. Fay, B.G. Ferris Jr, F.E. Speizer. 1993. An association between air pollution and mortality in six U.S. cities. *N Engl J Med.* Dec 9:329(24):1753-9.

Graham, R.T.; Harvey, A.E.; Jurgensen, M.F.; Jain, T.B.; Tonn, J.R; Page-Dumroese,D.S. 1994. Managing course woody debris in forests of the Rocky Mountains. Res. Pap. Int-477. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 13 p.

Guido, Zack. (2008). Southwest Climate Change Network. Southwest Climate Change Network Impacts of Fire

Haase, S.M. 1986. Effect of prescribed burning on soil moisture and germination of southwestern ponderosa pine seed on basaltic soils. Research Note RM-462. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 6 p.

Harvey, A. E., M. J.Geist, G. I. McDonald, M. F. Jurgenson, P. H. Cochran, D. Zabowski and R. T. Meurisse. 1994. Biotic and Abiotic Processes in Eastside Ecosystems: The Effects of Management on Soil Properties, Processes and Productivity. USDA Forest Service Pacific Northwest Research Station. General Technical Report PNW-GTR-323.

Hungerford, Roger D., M. G. Harrington, W. H. Frandsen, K. C. Ryan, and G. J. Neihoff. 1991. Influence of Fire on Factors that Affect Site Productivity. Paper presented at the Symposium on Management and Productivity of Western-Montane Forest Soils, **B**oise, ID, April 10-12, 1990.

Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Quin, M. Manninget al. Cambridge, United Kingdom, Cambridge University Press: 996.

Kaye, J.P., and S.C. Hart. 1998a. Ecological restoration alters N transformations in a ponderosa pine-bunchgrass ecosystem. Ecol. Appl. 8:1052–1060.

Korb, J.E., Nancy C. Johnson, and W.W. Covington. 2004. Slash Pile Burning Effects on Soil Biotic and Chemical Properties and Plant Establishment: Recommendations for Amelioration. Restoration Ecology Vol. 12 No. 1, pp. 52-62.

MacDonald, L.H.; Stednick, J.D. 2003. Forests and water: A state-of-the-art review for Colorado. Colorado Water Resources Research Institute Rep. No. 196. Fort Collins, CO. Colorado State University. 65 p.

Moldenke, Andrew. 1999. Soil-dwelling arthropods: their diversity and functional roles. In Proceedings: Pacific Northwest Forest and Rangeland Soil Organisms Symposium, Robert T. Meurisse, William G. Ypsilantis and Cathy Seybold, editors. USDA Forest Service, Pacific Northwest Research Station. PNW-GTR-461. Pg. 33-44.

National Research Council. 1994. Rangeland health – new methods to classify, inventory, and monitor rangelands. p. 97-105. National Academy Press. Washington D. C.

Neary, Daniel G., Carole C. Klopatek, Leonard F. DeBano and Peter F. Ffolliott. 1999. Fire effects on belowground sustainability: a review and synthesis. Forest Ecology and Management, Volume 122, Issues 1-2, Pg. 51-71.

Ottmar, R. D. 2001. Smoke Source Characteristics. Smoke Management Guide for Prescribed and Wildland Fire 2001 Edition. NWCG. PMS 420-2, NFES 1279. Boise, ID.

Ower, C.L.1985. Changes in ponderosa pine seedling growth and soil nitrogen following prescribed burning and manual removal of the forest floor. M.S.F. Thesis. Flagstaff, AZ: Northern Arizona University. 109 p.

Potyondy, John P. and Theodore W. Geier. 2011. Watershed Condition Classification Technical Guide. United States Department of Agriculture, Forest Service Technical Guide FS-978. 41 pp.

Ryan, M.G., and W.W. Covington. 1986. The effect of a prescribed burn in ponderosa pine on inorganic nitrogen concentrations of mineral soil. Research Note RM-464. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p.

Robichaud, Peter R. 2000. Fire effects on infiltration rates after prescribed fire in northern Rocky Mountain forests, USA. Journal of hydrology. 231-232(1-4): 220-229.

Seymour, Geoff and Aregai Tecle. 2005. Impact of Slash Pile Size and Burning on Soil Chemical Characteristics in Ponderosa Pine Forests. Journal of the Arizona-Nevada Academy of Science, Vol. 38, No. 1 (2005), pp. 6-20.

Stark, J.M. and S.C. Hart. 1997. High rates of nitrification and nitrate turnover in undisturbed coniferous forests. Nature 385 (1997), pp. 61–64.

Tiedemann, A. R. and T.D. Anderson. 1987. Combustion losses of sulfur from native plant materials and forest litter. In: Proceedings Sixth Conference on Fire and Forest Meterology, April 22-24, 1980. Society of American Foresters. Pages 220-227.

Tiedemann, Arthur R.; Conrad, Carol E.; Dieterich, John H. 1979. Effects of fire on water: a state-of-knowledge review. *In:* General Technical Report WO-10. USDA, Forest Service.

Truebe, M.; Evans, G. 1994. Lowell surfacing thickness design test road: Final report. Federal Highway Administration Report FHWA-FLP-94-008. USDA Forest Service. San Dimas Technology and Development Center. San Dimas, CA. 108 p.

USDA. 1990. Soil and Water Conservation Practices Handbook. Forest Service Handbook 2509.22. USDA Forest Service, Southwestern Region. pp 83.

USDA. 2012. National Best Management Practices for Water Quality Management on National Forest System Lands. Volume 1: National Core BMP Technical Guide. (FS-990a). 165 p.

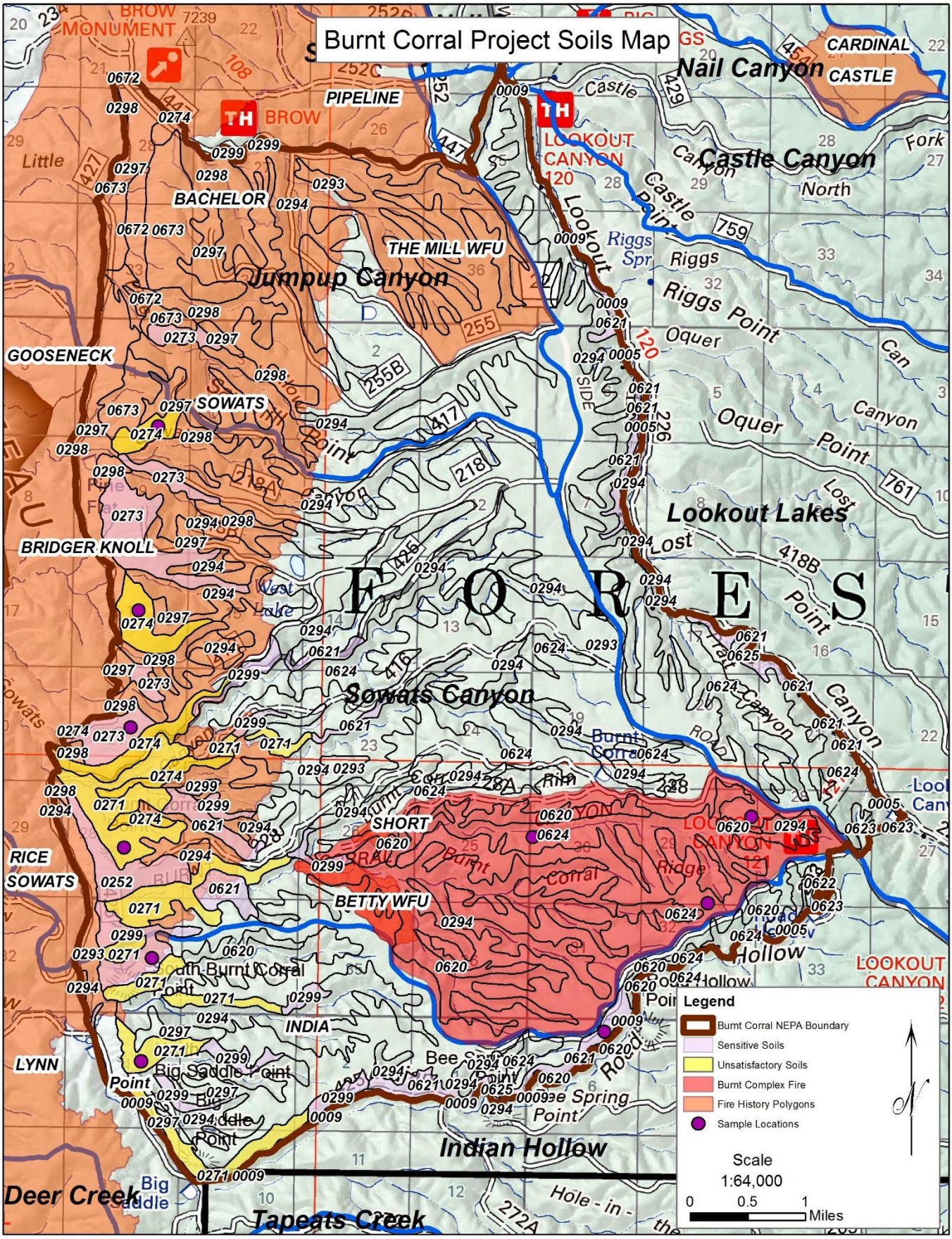
USDA. 2014. Land and Resource Management Plan for the Kaibab National Forest, as Amended. USDA Forest Service, Southwestern Region. 208 pp.

Ward, Timothy J. and Susan M. Bolton, Hydrologic Parameters for Selected Soils in Arizona and New Mexico as Determined by Rainfall Simulation: Available from National Technical Information Service, Springfield, VA 22161 as PB92-118207.

Ward, D. E., C. C. Hardy. 1991. Smoke emissions from wildland fires. Environmental International, Vol 17:117-134.

Appendix A

Burnt Corral Project Area Soils and Watershed Map


Burnt Corral Project Soils Map
Legend
Burnt Corral NEPA Boundary
Sensitive Soils
Unsatisfactory Soils
Burnt Complex Fire
Fire History Polygons
Sample Locations
Scale
1:64,000
0 0.5 1
Miles
Nail Canyon
Castle Canyon
Jumpup Canyon
Sowats Canyon
Lookout Lakes
Indian Hollow
Deer Creek
Tapeats Creek
BROW
PIPELINE
BACHELOR
THE MILL WFU
SOWATS
GOOSENECK
BRIDGER KNOLL
RICE
SHORT
BETTY WFU
INDIA
LYNN
LOOKOUT CANYON
CARDINAL CASTLE
Riggs Point
Oquer Point
Burnt Corral Ridge
Big Saddle Point

Appendix B

Burnt Corral Project Soil Condition Field Assessment Information

Burnt Corral Project.

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 0293	State AZ	County Coconino	Forest Kaibab	District N Kaibab	By	Date 8/30/16	
Watershed		Area		7 ½ Min. Quad	7 ½ Quad No.		
T. 36N R. 1E		S. 32 1/4 NE	1/4 N	Aerial Photo	Stop Number		
GPS File Name		Latitude		Longitude	UTM N/2S 0382281 E 4038281		
Soil Taxon					~~Phase~~ 0382282		
Vegetation Taxon			Climax Class		Climate Class		
Landform ridgetop		Parent Material chert		Bedrock	Elevation		
Slope Gradient 5 %		Length m	Aspect 300 °	Complexity	Shape	Contour	

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co st bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties
OM	0-2									
	2-7		CL	35% gr	7.5 YR 3/2 dry	gr				
	7-22		L	35% gr	7.5 YR 4/2 dry	sbk				
	22-38+		L	50% gr	7.5 YR 5/2 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%
Graminoids (ba)	
Forbs (ba)	
Shrubs/trees (ba)	
Litter (>1.25 cm)	
Gravel (.2-2 cm)	
Gravel (2-7.5 cm)	
Cobble	
Stone	
Boulder	
Rock outcrop	
Bare soil	
Biotic crust	

Modeled Soil Loss	T/h/yr
Potential:	
Current:	
Natural:	
Tolerance:	

OTHER OBSERVATIONS

Coarse woody material:	diameter number
Bulk density:	g/cc
Infiltration rate:	cm/hr
Penetration resistance (depth):	cm
Forage production:	lbs/ac/yr

Notes: Site covered in Ponderosa Pine needles & duff. Area burned over with charred stumps and logs. Large standing Ponderosa Pine singed on the butt and looking healthy. Some small Ponderosa & white fir dead from fire. Site stable. No erosion noted. No compaction. Photos 1 & 2. Present vegetation: Aspen, mountain mahogany, lupine, grass, white fir

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

Page 1 of 2

Photo 1. Map unit 293 in the Burnt Corral project area.

Photo 2. Map unit 293 in the Burn Corral project area.

Burnt Corral Project

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 0624	State AZ	County Coconino	Forest Kaibab	District N Kaibab	By	Date 8/30/16	
Watershed		Area		7 ½ Min. Quad		7 ½ Quad No.	
T. 36 N	R. 1E	S. 30 1/4 NW	1/4 W	Aerial Photo		Stop Number	
GPS File Name		Latitude		Longitude		UTM N 4037945 8 E 403901 3	
Soil Taxon					Phase 037945 8		
Vegetation Taxon			Climax Class			Climate Class	
Landform ridge		Parent Material chert		Bedrock		Elevation	
Slope Gradient 3 %		Length m	Aspect 330 °	Complexity	Shape	Contour	

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co st bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties
OM	0-2.5									
	2.5-19		L	45% gr	7.5YR 3.2 dry	weak sbk				
	19-41+		SL	60% gr	7.5YR 4/3 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%	Modeled Soil Loss	T/h/yr
Graminoids (ba)		Potential:	
Forbs (ba)		Current:	
Shrubs/trees (ba)		Natural:	
Litter (>1.25 cm)		Tolerance:	
Gravel (.2-2 cm)			
Gravel (2-7.5 cm)			
Cobble			
Stone			
Boulder			
Rock outcrop			
Bare soil			
Biotic crust			

OTHER OBSERVATIONS

Coarse woody material:	diameter number
Bulk density:	g/cc
Infiltration rate:	cm/hr
Penetration resistance (depth):	cm
Forage production:	lbs/ac/yr

Notes: Ground covered in needles & duff. Large Ponderosa Pine butts burned + trees healthy. some small ponderosa pines dead from fire, stumps & logs burned with remnants scattered about. Vegetation present: grass, ~~forbs~~, aspen, lupine. No erosion. No compaction. Site stable.

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

Photos 344

Page 1 of 2

Photo 3. Map unit 624 in the Burnt Corral project area.

Photo 4. Map unit 624 in the Burnt Corral Project.

Burnt Corral Project

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 0621	State AZ	County Coconino	Forest Kaibab	District N. Kaibab	By	Date 8/30/16
Watershed		Area		7 ½ Min. Quad	7 ½ Quad No.	
T. 35N R. 1E	S. 6 1/4 NE 1/4		Aerial Photo		Stop Number	
GPS File Name	Latitude	Longitude		UTM N/2503807 4/ E 403682		
Soil Taxon				Phase 0380741		
Vegetation Taxon		Climax Class			Climate Class	
Landform ridge	Parent Material chert		Bedrock		Elevation	
Slope Gradient Flat %	Length m	Aspect 0 °	Complexity	Shape	Contour	

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co st bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties
OM	0-2									
	2-15		CL	45% gr	7.5 YR 3/3 dry	vcabk sbk				
	15-34+		SCL	70% gr	7.5 YR 5/2 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%	Modeled Soil Loss	T/h/yr
Graminoids (ba)		Potential:	
Forbs (ba)		Current:	
Shrubs/trees (ba)		Natural:	
Litter (>1.25 cm)		Tolerance:	
Gravel (.2-2 cm)			
Gravel (2-7.5 cm)			
Cobble			
Stone			
Boulder			
Rock outcrop			
Bare soil			
Biotic crust			

OTHER OBSERVATIONS

Coarse woody material: diameter / number

Bulk density: g/cc

Infiltration rate: cm/hr

Penetration resistance (depth): cm

Forage production: lbs/ac/yr

Notes: No Fire evidence at this site. Ponderosa Pine in overstory. Vegetation present Grass, Mountain mahogany, lupine. Ground covered with duff & needles. No compaction. No erosion. Site Stable. sub horizon very rocky - didnt dig as deep as other sites. photos 5 & 6

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

Page 1 of 2

Photo 5. Map unit 621 in the Burnt Corral project area.

Photo 6. Map unit 621 in the Burnt Corral project area.

Burnt Corral Project

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 077	State AZ	County Coconino	Forest Kaibab	District N. Kaibab	By	Date 7/31/18
Watershed		Area		7 ½ Min. Quad	7 ½ Quad No.	
T. 36N R. 1W		S. 29 1/4 NE	1/4	Aerial Photo	Stop Number	
GPS File Name		Latitude	Longitude		UTM N/ 2505742 14E 463938	
Soil Taxon					Phase 0974214	
Vegetation Taxon			Climax Class		Climate Class	
Landform Ridgeshoulder		Parent Material chert		Bedrock	Elevation	
Slope Gradient 7/8 %		Length m	Aspect 19 °	Complexity	Shape	Contour

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr cb st bd (% Vol)	p/d p/m p/o p/r	gr si sh	dr mo st pl	qu si fo	qu si lo	Accessory Properties
OM	trace									
	0-18		CL	25% gr	7.5YR 3/2 dry	sbk				
	18-38+		C	0% gr 20% cob	7.5YR 6/4 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#/a	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%
Graminoids (ba)	
Forbs (ba)	
Shrubs/trees (ba)	
Litter (>1.25 cm)	
Gravel (.2-2 cm)	
Gravel (2-7.5 cm)	
Cobble	
Stone	
Boulder	
Rock outcrop	
Bare soil	
Biotic crust	

Modeled Soil Loss	T/ha/yr
Potential:	
Current:	
Natural:	
Tolerance:	

OTHER OBSERVATIONS

Coarse woody material:	diameter / number
Bulk density:	g/cc
Infiltration rate:	cm/hr
Penetration resistance (depth):	cm
Forage production:	lbs/ac/yr

Notes: Vegetation present; Oak, a 2 needle pine, cliff rose, service berry, juniper, grass, ponderosa pine. In old fire scar No unnatural erosion. no compaction site stable. 15% bare ground - bare ground 70% covered in gravel. Pried 5 cobbles out of 38cm pit. Dug until I hit locked cobbles.

photos 7 & 8

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

Page 1 of 2

Photo 7. Map unit 271 in the Burnt Corral project area.

Photo 8. Map unit 271 in the Burn Corral project area.

Burnt Corral Project

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 0273	State AZ	County Coconino	Forest Kaibab	District N. Kaibab	By	Date 8/3/16
Watershed		Area		7 ½ Min. Quad	7 ½ Quad No.	
T. 36N R. 1W		S. 21 1/4 NW	1/4 SE	Aerial Photo	Stop Number	
GPS File Name	Latitude		Longitude		UTM N 3503740 E 404073 2	
Soil Taxon					Phase 0374042	
Vegetation Taxon		Climax Class			Climate Class	
Landform Side slope	Parent Material clast		Bedrock		Elevation	
Slope Gradient 25 %	Length m	Aspect 301 °	Complexity	Shape	Contour	

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co si bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties
OM	trace									
	0-16±2		L	40% gr	7.5 YR 3/3 dry	weak sbk				
	16±2-41±		SC	20% gr	7.5YR 4/4 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%	Modeled Soil Loss	T/ft/yr
Graminoids (ba)		Potential:	
Forbs (ba)		Current:	
Shrubs/trees (ba)		Natural:	
Litter (>1.25 cm)		Tolerance:	
Gravel (.2-2 cm)			
Gravel (2-7.5 cm)			
Cobble			
Stone			
Boulder			
Rock outcrop			
Bare soil			
Biotic crust			

OTHER OBSERVATIONS

Coarse woody material: diameter / number

Bulk density: g/cc

Infiltration rate: cm/hr

Penetration resistance (depth): cm

Forage production: lbs/ac/yr

Notes: Vegetation present: brush Field with oak, service berry, grass, shrubs. Old fire scar. Site stable. No compaction. No erosion natural. 25% bare ground - 75% of bare ground covered in gravel.

photos 9 to 10

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

Page 1 of 2

Photo 9. Map unit 273 in the Burnt Corral project area.

Photo 10. Map unit 273 in the Burnt Corral project area.

Burnt Corral Project

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

(Reference FSH 2509.18) *Designed for Hardcopy Only Use*

Map Symbol 0274	State AZ	County Coconino	Forest Kaibab	District N. Kaibab	By	Date 9/2/16
Watershed		Area		7 ½ Min. Quad	7 ½ Quad No.	
T. 36N R. 1W		S. 16 1/4 NW	1/4 SE	Aerial Photo	Stop Number	
GPS File Name		Latitude	Longitude		UTM N 4037424 E 4042285	
Soil Taxon					~~Phase~~ 037424 3	
Vegetation Taxon			Climax Class		Climate Class	
Landform midslope		Parent Material chert		Bedrock		Elevation
Slope Gradient 17 %		Length m	Aspect 271 °	Complexity	Shape	Contour

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co st bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties
OM	trace									
	0-15		SCL	40% gr	7.5 YR 3/2 dry	weak sbk				
	15-41		CL	50% gr	7.5 YR 4/3 dry	sbk				

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%	Modeled Soil Loss	T/h/yr
Graminoids (ba)		Potential:	
Forbs (ba)		Current:	
Shrubs/trees (ba)		Natural:	
Litter (>1.25 cm)		Tolerance:	
Gravel (.2-2 cm)			
Gravel (2-7.5 cm)			
Cobble			
Stone			
Boulder			
Rock outcrop			
Bare soil			
Biotic crust			

OTHER OBSERVATIONS

Coarse woody material:	diameter / number
Bulk density:	g/cc
Infiltration rate:	cm/hr
Penetration resistance (depth):	cm
Forage production:	lbs/ac/yr

Notes: Vegetation present: shrub land: Oak, service berry, cats claw, grass, forbs. 80% of ground surface covered in litter & duff. Old Fire Scar, 20% bare ground - 50% of bare ground covered with gravel. No Compaction. no unnatural erosion. Site stable.

1/ Number of regenerating trees (<5" dbh) in plot

2/ Sample area of 375 square meter circular plot

photos 11812

Page 1 of 2

Photo 11. Map unit 274 in the Burnt Corral project area.

Photo 12 Map unit 274 in the Burnt Corral project area.

Appendix C

Watershed condition indicator ratings and watershed condition summary

Subwatershed Name	Subwatershed Acres	Forest Service (FS) Acres	Non FS Acres	Percent FS Acres	Percent Non FS Acres	Overall Watershed Score	Aquatic Biological Average	Aquatic Physical Average	Terrestrial Physical Average	Terrestrial Biological Average	Watershed Score FS Average	Watershed Score Non FS Average	Watershed Condition Summary
Castle Canyon	11176	11157	19	100	0	2.3	2.5	2.3	2.1	2.2	2.3	2.3	Fire regime departed from reference condition; high road density; low road maintenance; many tanks present; high insect and disease risk.
Indian Hollow	32686	30301	2385	93	7	2.5	2.5	2.7	2.3	2.1	2.5	2.5	Reduced flows to springs and riparian areas (4 springs; 4 acres of riparian habitat); fire regime departed from reference condition; high road density; low road maintenance; many tanks present.
Jumpup Canyon	36891	35825	1065	97	3	2.4	2.5	2.7	2.3	2.5	2.4	2.4	Moderate to high burn severity - Bridger Knoll Fire 1996; reduced flows to springs and riparian areas (4 springs; 73 acres of riparian habitat; fire regime departed from reference condition; low road maintenance; many tanks present; high noxious weeds infestation (Scotch thistle)

Subwatershed Name	Subwatershed Acres	Forest Service (FS) Acres	Non FS Acres	Percent FS Acres	Percent Non FS Acres	Overall Watershed Score	Aquatic Biological Average	Aquatic Physical Average	Terrestrial Physical Average	Terrestrial Biological Average	Watershed Score FS Average	Watershed Score Non FS Average	Watershed Condition Summary
Lookout Lakes	38735	38735	0	100	0	2.3	2.5	2.5	2	2	2.3		Reduced flows to springs and riparian areas (3 springs and 30 acres of riparian habitat); high road density; low road maintenance; many tanks present; high insect and disease risk.
Nail Canyon	17609	17608	2	100	0	2.4	2.5	2.5	2.3	2.1	2.4	2.4	Moderate to high burn severity - Warm Fire 2006; reduced flows to springs and riparian areas (10 springs; 24 acres of riparian habitat; high road density; low road maintenance; many tanks present; high noxious weed infestation (cheatgrass).
Sowats Canyon	39580	39579	2	100	0	2.5	2.5	2.7	2.3	2.3	2.5	2.5	Moderate to high burn severity - Bridger Knoll Fire 1996; reduced flows to springs and riparian areas (15 springs; 129 acres of riparian habitat); fire regime departed from reference condition; high road density; low road

Subwatershed Name	Subwatershed Acres	Forest Service (FS) Acres	Non FS Acres	Percent FS Acres	Percent Non FS Acres	Overall Watershed Score	Aquatic Biological Average	Aquatic Physical Average	Terrestrial Physical Average	Terrestrial Biological Average	Watershed Score FS Average	Watershed Score Non FS Average	Watershed Condition Summary
													maintenance; many tanks present;